



# Social Organization Standard

T/CAOE 21.11-2020

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## Technical guideline on coastal ecological rehabilitation for hazard mitigation —

### Part 11:

### Supervising and monitoring

海岸带生态减灾修复技术导则 第 11 部分：监管监测

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## Foreword

The T/CAOE 21 *Technical guideline on coastal ecological rehabilitation for hazard mitigation* consists of the following eleven parts:

- Part 1: *General*;
- Part 2: *Mangroves*;
- Part 3: *Salt marshes*;
- Part 4: *Coral reefs*;
- Part 5: *Seagrass bed*;
- Part 6: *Oyster reef*;
- Part 7: *Sandy coast*;
- Part 8: *Technical guide for the ecological construction of sea walls (trial)*;
- Part 9: *Renovation of island-connecting sea wall and coastal engineering*;
- Part 10: *Directives for sea dike ecological construction of sea reclamation and enclosure project*;
- Part 11: *Supervising and monitoring*.

This is part 11 of the T/CAOE 21.

This part is drafted in accordance with the rules given in the GB/T 1.1-2009.

This part was proposed by *the Marine Early Warning and Monitoring Division, Ministry of Natural Resources*.

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# Technical guideline for coastal ecological rehabilitation for hazard mitigation —

## Part 11: Supervising and monitoring

### 1 Scope

This part of T/CAOE 21 specifies the objectives, working procedures, technical requirements, document archiving, etc., for the supervising and monitoring of coastal ecological rehabilitation for hazard mitigation projects.

This section is applicable to the superior authorities for monitoring, evaluating, supervising, and monitoring the ecological effects and natural hazard mitigation effects of coastal ecological rehabilitation for hazard mitigation projects. Other related work, including tracking, monitoring, and evaluating the local coastal ecological rehabilitation, for hazard mitigation projects can be used as references.

### 2 Normative references

The listed documents are essential for the application of this document. For dated reference documents, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

- GB/T 12763.2 Marine survey specification-Part 2: Marine hydrological observation
- GB/T 12763.4 Marine survey specification- Part 4: Seawater chemical element survey
- GB/T 12763.6 Specification for marine survey- Part 6: Marine biological survey
- GB/T 12763.8 Specification for Marine Survey- Part 8: Marine Geology and Geophysical Survey
- GB/T12763.10 Marine Survey Specification- Part 10: Submarine Topography and Geomorphology Survey
- GB 17378.3 Marine Monitoring Specification- Part 3: Sample Collection, Storage and Transportation
- GB 17378.4 Marine Monitoring Specification- Part 4: Seawater Analysis
- GB 17378.5 Marine Monitoring Specification- Part 5: Sediment Analysis
- GB 17378.7 Marine Monitoring Specification- Part 7: Ecological Investigation and Biological Monitoring of Offshore Pollution
- GB/T 17501 Guidelines for Topographic Survey of Ocean Engineering
- GB/T 19485 Technical Guidelines for Environmental Impact Assessment of Marine Engineering
- HY/T 080 Technical Regulations for Coastal Wetland Ecological Monitoring
- HY/T 081 Technical Regulations for Mangroves Ecological Monitoring
- HY/T 147.1 Technical Regulations for Marine Monitoring Part 1: Seawater
- HY/T 255 Technology Guide for Beach Maintenance and Repairment
- LY/T 1820 Technical Regulations for Investigation of Wild Plant Resources
- NY/T 1121.16 Soil Testing Part 16: Determination of Total Water-soluble Salt in Soil
- T/CAOE 20 Technical Guidelines for Investigation and Evaluation of the Status Quo of Coastal Ecosystem (all parts).
- T/CAOE 21 Technical guidelines for coastal ecological rehabilitation for hazard mitigation (all parts).

### 3 Terms and definitions

The following terms and definitions apply to the present document.

## 3.1

**supervising and monitoring**

it means the higher-level competent authority organized work, including the investigation, sampling, and analyzing the progress or the implementation of the coastal ecological rehabilitation for hazard mitigation project, to provide support for project effect evaluation and supervision and management.

**4 General****4.1 Objective of supervising and monitoring**

Through tracking and monitoring of the coastal ecological rehabilitation for hazard mitigation project, the ecological rehabilitation effect of the project implementation, the effect of disaster prevention and reduction, and its impact on the surrounding coastal ecological environment are evaluated. It can provide a scientific basis for the supervision of the coastal ecological rehabilitation for the hazard mitigation project. It can also ensure the ecological hazard mitigation benefits of the coastal ecosystem zone being effectively improved.

**4.2 Principle of supervising and monitoring**

The supervising and monitoring of coastal ecological rehabilitation for hazard mitigation projects shall obey the following principles:

—Scientifically rigorous. Tracking and monitoring plans and evaluation methods shall be scientifically planned, and the effects of coastal ecological rehabilitation for hazard mitigation projects and the impact on surrounding ecosystems shall be objectively monitored and evaluated.

—Timely monitoring. In the process of the project, after the completion of the project, or when encountering major emergencies, tracking monitoring and evaluation of the project shall be timely carried out.

—Classified policies. According to the different requirements of different types of coastal ecological rehabilitation for hazard mitigation projects, including the ecological effect, hazard mitigation effect, ecological impact, etc. a targeted tracking monitoring and evaluation plan shall be designed.

**4.3 Object of supervising and monitoring**

According to the provisions of T/CAOE 21.1, there are seven types of coastal ecological rehabilitation for hazard mitigation projects, including mangrove ecological rehabilitation for hazard mitigation, salt marsh ecological rehabilitation for hazard mitigation, coral reef ecological rehabilitation for hazard mitigation, seagrass bioecological rehabilitation for hazard mitigation, oyster reef ecological rehabilitation for hazard mitigation, and sandy shore ecological rehabilitation for hazard mitigation, and ecological sea dike reforming as shown in (Table 1). The object of supervising and monitoring can be coastal ecological rehabilitation for hazard mitigation projects of a single type or composited multiple types.

Table 1 — The objects and priorities of supervising and monitoring for coastal ecological rehabilitation for hazard mitigation projects

Type	Objects	Priorities
1	Mangrove ecological rehabilitation for hazard mitigation	Mangrove ecosystem structure, Ability to eliminate waves and slow currents
2	Salt marsh ecological rehabilitation for hazard mitigation	Salt marsh ecosystem rehabilitation, Ability to eliminate waves and promote siltation

3	Coral reef ecological rehabilitation for hazard mitigation	Coral reef ecosystem rehabilitation, Ability to eliminate waves and slow currents
4	Seagrass beds ecological hazard mitigation and rehabilitation	Recovery of seagrass bed area, Ability to eliminate waves and slow currents
5	Oyster reef ecological rehabilitation for hazard mitigation	Recovery of oyster reef, Ability to eliminate waves and slow currents
6	Sandy coast ecological rehabilitation for hazard mitigation	Disaster mitigation capacity of sandy coast, Beach geomorphological system stability, the ecological environment of sandy coast
7	Ecological sea dike reforming	Connectivity of sea and land ecosystems, The structure of coastal ecosystems, the ability of seawall to resist storm surge and disasters

#### 4.4 Content of supervising and monitoring

Supervising and monitoring include three parts: tracking monitoring, effect evaluation, and supervision and management:

——Tracking and monitoring include two stages i.e., during the rehabilitation process and after the completion of rehabilitation. Tracking and monitoring during the rehabilitation process cover three parts: the tracking and monitoring of the rehabilitation effect, the tracking and monitoring of the surrounding ecological impact, and the monitoring of threat factors. Tracking and monitoring after the completion of rehabilitation include three parts: ecological effect, hazard mitigation effect, and threat factors.

——The effect evaluation includes ecological effect evaluation, hazard mitigation effect evaluation, ecological impact evaluation, etc. After each tracking monitoring is completed, the implementation effect and ecological impact of the rehabilitation project must be evaluated.

——Designing the engineering regulatory measures according to the results of monitoring and evaluation.

### 5 Working procedures

#### 5.1 Data preparation

For coastal ecological rehabilitation for hazard mitigation engineering, collect data including the approved company implementation plan, feasibility study report, basic information of the project, historical data of the ecological environment of the sea area, background data of the sea area, etc., shall be collected

#### 5.2 Scheme preparation

The implementation plan for the supervising and monitoring of coastal ecological rehabilitation for hazard mitigation projects shall be prepared. The plan shall specify the scope of monitoring, station layout, monitoring indicators, monitoring methods, monitoring time, monitoring frequency, evaluation methods, etc.

When multiple types are included in the same project, the monitoring plan should cover the required monitoring contents for all included types.

The outline of supervising and monitoring the implementation plan for coastal ecological rehabilitation for hazard mitigation projects shall meet the requirements of Annex A

#### 5.3 On-site investigation

According to the supervising and monitoring implementation plan of coastal ecological rehabilitation for hazard mitigation projects, the tracking and monitoring of coastal ecological rehabilitation for hazard mitigation projects should be organized during the rehabilitation process

and after the completion of rehabilitation.

#### 5.4 Analysis and evaluation

According to the results of tracking and monitoring, ecological effect of engineering, effect evaluation of hazard mitigation, and ecological impact assessment are carried out using methods such as data comparison before and after the project or grade estimation of water and sediment quality, to determine project evaluation grade and supervision results.

#### 5.5 Report preparation

According to the results of tracking, monitoring, and evaluation, the supervising and monitoring report of coastal ecological rehabilitation for hazard mitigation projects will be compiled to provide data support and a decision-making basis for project supervision and management.

The supervising and monitoring reports of coastal ecological rehabilitation for hazard mitigation projects should include informative and accurate data, and clear conclusions. The preparation outline of the report should meet the requirements of Annex B.

### 6 Tracking and monitoring content

#### 6.1 Determination of monitoring scope

The tracking and monitoring scope should cover the entire range and extend to the surrounding 1km to 3km area of the coastal ecological rehabilitation for hazard mitigation projects, which will be used for ecological impact assessment.

#### 6.2 Monitoring contents and methods

Tracking monitoring includes three categories: monitoring of the rehabilitation effect, monitoring of the ecological impact, and monitoring of threat factors:

—The monitoring content of the rehabilitation effect mainly includes monitoring items that can directly reflect the project's rehabilitation objectives.

—The monitoring content of the ecological impact mainly includes marine ecological environment monitoring items such as biological communities, water environment, and sedimentary environment.

—The monitoring content of threat factors mainly includes factors of natural disaster and harms due to human development and utilization activities.

The primary tracking and monitoring contents of the rehabilitation process are the ecological impacts and the rehabilitation results. The primary tracking and monitoring contents after the completed rehabilitation are the rehabilitation results.

Table 2 and Table 3 specify the principal monitoring contents of different types of coastal ecological rehabilitation for hazard mitigation projects. For the specific tracking monitoring indicators and monitoring methods of each type of project, see Annex C. When tracking and monitoring work is implemented, the monitoring indicators shall be selected and determined by the specific objectives and actual conditions of the rehabilitation project.

Table 2 — Tracking and monitoring contents during the implementation of coastal ecological rehabilitation for hazard mitigation projects

Monitoring content		Project type						
		Mangroves	Salt marshes	Coral reefs	Seagrass bed	Oyster reef	Sandy coast	Ecological sea dike
Rehabilitation results	Vegetation	★	★		★		☆	★
	Reef			★		★		
	Pests	☆	☆	☆	☆	☆		
	Dune						★	☆
Ecological impact	Biomes	★	★	★	★	★	★	★
	Water	★	★	★	★	★	★	★



	environment							
	Sedimentary environment	★	★	★	★	★	★	★
Threat factors	Natural disaster	☆	☆	☆	☆	☆	☆	☆
	Human activity	☆	☆	☆	☆	☆	☆	☆
NOTE ★ is a required test index, ☆ is an optional test index.								

Table 3 — Tracking and monitoring indicators after the completion of the coastal ecological rehabilitation for hazard mitigation project

Monitoring content		project type						
		Mangroves	Salt marshes	Coral reefs	Seagrass bed	Oyster reef	Sandy coast	Ecological sea wall
Ecological impact	Vegetation	★	★		★		☆	★
	Reef			★		★		
	Pests	☆	☆	☆	☆	☆		
	Dune						★	☆
	Hydrodynamics						☆	★
	Niomes	★	★	★	★	★	★	★
	Water environment	★	★	☆	★	☆	☆	☆
	Sedimentary environment	★	★	☆	★	☆	★	☆
Effect of hazard mitigation	Capacity of hazard mitigation	★	★	★	★	★	★	★
Threat factors	Natural disaster	☆	☆	☆	☆	☆	☆	☆
	Human activities	☆	☆	☆	☆	☆	☆	☆
NOTE ★ is a required test index, ☆ is an optional test index.								

### 6.3 Layout of monitoring stations

#### 6.3.1 Principles of station deployment

The layout principles of tracking and monitoring stations specified in the guidelines are shown as follows:

- The monitoring stations should cover the entire project area and ecologically affected area, and be arranged as evenly as possible.
- The layout of monitoring stations should be representative and able to include all rehabilitation types involved in the project.
- The monitoring stations shall use historical stations as much as possible to facilitate comparison between the monitoring content before and after the project construction.
- Once the monitoring station is determined, it should remain unchanged in order to provide a basis for continuous management.

#### 6.3.2 Station deployment method

For different types of coastal ecological rehabilitation for hazard mitigation projects, the station layout methods are respectively specified:

- The layout method of tracking and monitoring stations for mangroves ecological rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of 6.1 of T/CAOE 20.3.
- The layout method of tracking and monitoring stations for the salt marshes ecological rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of 6.1 of T/CAOE 20.4.
- The layout method of tracking and monitoring stations for the coral reef ecological rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of parts 6.2, 6.3, and 7.1 of T/CAOE 20.5.
- The layout method of tracking and monitoring stations for the seagrass bed ecological

rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of 6.2 of T/CAOE 20.6.

—The layout method of tracking and monitoring stations for the oyster reef ecological rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of 6.1 and 6.2 of T/CAOE 20.7.

—The layout method of tracking and monitoring stations for the sandy coast ecological rehabilitation for hazard mitigation projects shall be implemented in accordance with the provisions of Part 6 of T/CAOE 20.8.

—The tracking and monitoring sections for ecological sea dike reforming are arranged perpendicular to the coastal zone, and the stations on each section shall cover the front, back, top, and intertidal zones of the ecological seawall involved in the project.

The observations of hazard mitigation functions of all projects are arranged in a cross-section. Every cross-section has no less than two measurement points, which are located at the front and back measurement points of the rehabilitation area, respectively. The section should be as parallel as possible to the wave direction and cover the entire rehabilitation area. In order to avoid the significant impact of topographical changes on the evaluation of hazard mitigation functions, the cross-section should be arranged in areas with relatively flat terrain and no significant changes. When the rehabilitation area contains multiple biological communities, multiple observation sections of hazard mitigation should be deployed.

If the rehabilitation project involves the hydrodynamic survey of waves, ocean currents, suspended sands, tide levels, wind, and regional sea levels, the station layout and technical requirements shall be implemented in accordance with the regulations in HY/T 255.

#### 6.4 Monitoring time and frequency

##### 6.4.1 Monitoring time

The tracking and monitoring time during the implementation of the rehabilitation process should be as consistent as possible with the background investigation period before the start of the project.

After the completion of the coastal rehabilitation, the project organization units shall complete the monitoring, evaluating, and accepting project within one year. The supervising and monitoring of the competent authority should be organized and carried out according to the situation within two years after the project is accepted. Long-term tracking and evaluating the project can also be carried out if necessary. The monitoring time should cover the typical representative season and the background investigation period before the project.

The tracking and monitoring time of coastal ecological rehabilitation for hazard mitigation projects shall follow the laws of biological growth and development.

—The tracking and monitoring of vegetation rehabilitation as the main body should be carried out during the flowering and fruiting seasons of plants. The best monitoring period should be determined in detail according to local climate and plant growth and development characteristics.

—The tracking and monitoring of animal rehabilitation as the main body should be carried out in the biological maturity season. The best monitoring period should be determined in detail according to the local climate and animal growth and development characteristics.

—The monitoring of wetland birds should be carried out during the breeding season, winter, and migration season. The best monitoring time should be determined according to local phenological characteristics.

The tracking and monitoring of hazard mitigation effects should be carried out after the planted biological community is stabilized.

—Planting forests dominated by fast-bodied species of mangroves can be monitored and evaluated for hazard mitigation in one to two years. Planting forests of general species can be monitored and evaluated in two to four years.

—For coral reefs, monitoring and evaluation of hazard mitigation shall be carried out when the project is implemented after five to ten years.

#### 6.4.2 Monitoring frequency

The tracking and monitoring of coastal ecological rehabilitation for hazard mitigation projects should be carried out in all key times during the construction period to ensure timely supervision of rehabilitation effects:

—At least one tracking and monitoring shall be carried out during the implementation of the rehabilitation process.

—At least one tracking and monitoring shall be carried out after the completion of the coastal rehabilitation, and multiple tracking and monitoring can also be carried out according to the needs of long-term tracking and evaluation.

—Monitoring should be increased before and after extreme weather such as typhoons or strong storm surges. Monitoring should start from one to three days before the extreme weather warning until the warning is released.

### 7 Technical requirements for ecological rehabilitation assessment

#### 7.1 Evaluation during the rehabilitation process

##### 7.1.1 Evaluation method

The evaluation during the rehabilitation process includes two aspects: effect evaluation of project construction and evaluation of ecological impact.

—The rehabilitation effect is evaluated by comparison to the target values, and the evaluation indicators are shown in Table 4. The requirements of the technical engineering plan are adopted as the target values. By comparison between the monitoring indicators and the target values, whether the project achieves the expected rehabilitation effect or not, is evaluated.

—The assessment method of ecological effect is implemented in accordance with the relevant regulations in GB/T 19485. The assessment indicators include the indicators of the biological community, water environment, and sedimentary environment in Annex C.

Table 4 — Indicators of effect evaluation during the rehabilitation process

Serial number	Project type	Evaluation index of rehabilitation effect
1	Mangroves ecological rehabilitation for hazard mitigation	Planting species, Area, Seedling density, Planting survival rate, Pest elimination rate
2	Salt marshes ecological rehabilitation for hazard mitigation	Planting species, Area, Density, Planting Survival rate, Pest elimination rate
3	Coral reefs ecological rehabilitation for hazard mitigation	Living reefs-building coral species, Coverage rate, Transplant survival rate, Pest elimination rate
4	Seagrass bed ecological rehabilitation for hazard mitigation	Planting species, Density, Coverage, Planting survival rate, Pest elimination rate
5	Oyster reef ecological rehabilitation for hazard mitigation	Transplant type, Area, Height, Density, Number of live oysters
6	Sandy coast ecological rehabilitation for hazard mitigation	Coastline length, Coastline location, Beach landforms, Sediment grain size,
7	Ecological sea dike reforming	Types of planting vegetation, Density, Survival rate, Shoreline location, Sediment grain size

### 7.1.2 Regulatory measures

According to the evaluation results during the rehabilitation process, if the index of rehabilitation effects does not meet the project's target values, the rehabilitation project causes the loss of marine biological resources, or the seawater and sediment environment cannot meet the environmental quality requirements of the functional zone, the construction party shall be ordered to suspend the rehabilitation project and to propose a modification plan or corrective measures.

## 7.2 Evaluation after the completion of the rehabilitation

### 7.2.1 Evaluation Index

After the rehabilitation is completed, the evaluation indicators cover indicators of ecological effect and indicators of hazard mitigation effect. The evaluation indicators of various rehabilitation projects are shown in Table 5.

Table 5 — Evaluation indexes and calculation basis after the completion of the rehabilitation

Serial number	Project type	Evaluation index	Calculation basis
1	Mangroves ecological rehabilitation for hazard mitigation	Mangroves area change, Coverage change, The change of number species, The survival rate of planting mangroves, Changes in the number or area of pests, Macrobenthic diversity index, Dissolved oxygen in water, Wave dissipative rate	T/CAOE 20.3 T/CAOE 21.2
2	Salt marshes ecological rehabilitation for hazard mitigation	Changes in the area of salt marshes, Changes in vegetation coverage, Changes in the number or area of pests, Changes in the density of macrobenthos, macrobenthos biomass changes, Sediment organic carbon, Wave dissipative rate	T/CAOE 20.4 T/CAOE 21.3
3	Coral reefs ecological rehabilitation for hazard mitigation	Changes in the number of reef-building coral species, Changes in coverage, Changes in recruitment, Changes in the number or area of pests, Changes in the density of coral reefs fish species, Changes in the density of macrobenthic, Wave dissipative rate	T/CAOE 20.5 T/CAOE 21.4
4	Seagrass bed ecological rehabilitation for hazard mitigation	Changes in the area of seagrass bed, Coverage change, Changes in density, Changes in the number or area of pests, Changes in macrobenthic biomass, Dissolved oxygen in water, Inorganic nitrogen in the water, Active phosphate in water, The organic carbon in sediment, Sulfide in sediment, Wave dissipative rate	T/CAOE 20.6 T/CAOE 21.5
5	Oyster reef ecological rehabilitation for hazard mitigation	Changes in the area of oyster reef, Changes in reef height, Changes in the density of live oyster, Changes in recruitment, Changes in the number or area of pests, Wave dissipative rate	T/CAOE 20.7 T/CAOE 21.6
6	Sandy coast ecological rehabilitation for hazard mitigation	Coastal stability, Beach topography, Sediment type, Relative tidal range, Biomass change in intertidal zones, Wave dissipative rate	T/CAOE 20.8 T/CAOE 21.7
7	Ecological sea dike reforming	Backshore vegetation area, Coverage, Beach widths, Biomass change in intertidal zones, Wave dissipative rate	T/CAOE 21.8 T/CAOE 21.9 T/CAOE 21.10

### 7.2.2 Evaluation method

#### 7.2.2.1 Calculation method and assignment of evaluation index

Classification and assignment of the evaluation index of various coastal ecological rehabilitation

for hazard mitigation projects, as shown in Table 6.

a) The calculation of change rate before and after rehabilitation

The method of comparison before and after rehabilitation is used to evaluate the index of rehabilitation effect, and the calculation of change rate  $V$  before and after rehabilitation is shown in Eq. (1):

$$V_i = \frac{A_i - A_{0i}}{A_{0i}} \times 100\% \quad \dots\dots\dots (1)$$

Where

$V_i$  is the  $i^{\text{th}}$  index of the rate of change before and after rehabilitation;

$A_i$  is the measured value of the  $i^{\text{th}}$  index after the completion of the rehabilitation;

$A_{0i}$  is the actual measured value of the  $i^{\text{th}}$  index before the rehabilitation.

b) Calculation of wave dissipative rate

The calculation of wave dissipative rate  $R_{wL}$  is shown in formula (2):

$$R_{wL} = \frac{H_0 - H_L}{H_0} \times 100\% \quad \dots\dots\dots (2)$$

Where

$R_{wL}$  Wave dissipative rate, meaning the ratio of the wave height attenuation ( $H_0 - H_L$ ) to the incoming wave height  $H_0$  after the wave passes through the engineering zone of width  $L$  during the storm surge. Its classification and assignment are shown in Table 6;

$H_0$  The effective wave height at the edge (front-measurement point) of the coastal side of the rehabilitation project, in meters (m);

$H_L$  The effective wave height at the rear edge of the rehabilitation project (post-measurement point), in meters (m).

c) Other indicators

For these indexes, including coastal stability, beach geomorphic characteristics, sediment types, relative tidal range, beach width, planting survival rate, biodiversity, water quality, sediments, etc., the change rates are not calculated before and after the rehabilitation project. These indexes are classified and assigned according to the actual measured values, as the following Table 6.

Table 6 — Classification and assignment of evaluation indicators after the completion of the rehabilitation

Project type	Evaluation index	Assignment			
		80 (Significant improvement)	60 (Improvement)	40 (Basically no change)	20 (No improvement)
Mangroves ecological rehabilitation for hazard mitigation	Change in the mangroves area	$\geq 10\%$	$\geq 5\% - < 10\%$	$\geq 0 - < 5\%$	$< 0$
	Change in vegetation coverage	$\geq 10\%$	$\geq 5\% - < 10\%$	$\geq 0 - < 5\%$	$< 0$
	Changes in the number of mangroves species	$\geq 60\%$	$\geq 20\% - < 60\%$	$\geq 0 - < 20\%$	$< 0$
	Mangroves planting survival rate	$\geq 75\%$	$\geq 45\% - < 75\%$	$\geq 10\% - < 45\%$	$< 10\%$
	Changes in the number or area of pests	$\leq -50\%$	$> -50\% - \leq -20\%$	$> -20\% - \leq 0$	$> 0$
	Macrobenthic diversity index	$\geq 2$	$\geq 1 - < 2$	$\geq 0.5 - < 1$	$< 0.5$
	Dissolved oxygen in water (mg/L)	$\geq 5$	$\geq 4 - < 5$	$\geq 3 - < 4$	$< 3$
	Wave dissipative rate	$\geq 80\%$	$\geq 60\% - < 80\%$	$\geq 30\% - < 60\%$	$< 30\%$
Salt marshes ecological rehabilitation	Change in salt marshes area	$\geq 10\%$	$\geq 5\% - < 10\%$	$\geq 0 - < 5\%$	$< 0$
	Changes in vegetation coverage of salt marshes	$\geq 10\%$	$\geq 5\% - < 10\%$	$\geq 0 - < 5\%$	$< 0$

Project type	Evaluation index	Assignment			
		80 (Significant improvement)	60 (Improvement)	40 (Basically no change)	20 (No improvement)
for hazard mitigation	Changes in the number or area of pests	$\leq -50\%$	$> -50\% \leq -20\%$	$> -20\% \leq 0$	$> 0$
	Changes in macrobenthic density	$\geq 10\%$	$\geq 5\% < 10\%$	$\geq 0 < 5\%$	$< 0$
	Changes in macrobenthic biomass	$\geq 10\%$	$\geq 5\% < 10\%$	$\geq 0 < 5\%$	$< 0$
	Sediment organic carbon	$\leq 2$	$> 2 \leq 3$	$> 3 \leq 4$	$> 4$
	Wave dissipative rate	$\geq 60\%$	$\geq 30\% < 60\%$	$\geq 10\% < 30\%$	$< 10\%$
Coral reef ecological rehabilitation for hazard mitigation	Changes in the number of reef-building coral species	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in reef-building coral coverage	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in reef-building coral recruitment	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in the number or area of pests	$\leq -50\%$	$> -50\% \leq -20\%$	$> -20\% \leq 0$	$> 0$
	Changes in coral reefs fish density	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in macrobenthic density	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Wave dissipative rate	$\geq 40\%$	$\geq 30\% < 40\%$	$\geq 20\% < 30\%$	$< 20\%$
Seagrass bed ecological rehabilitation for hazard mitigation	Changes in the area of seagrass bed	$\geq 15\%$	$\geq 5\% < 15\%$	$\geq 0 < 5\%$	$< 0$
	Changes in the seagrass cover	$\geq 15\%$	$\geq 5\% < 15\%$	$\geq 0 < 5\%$	$< 0$
	Changes in the seagrass density	$\geq 15\%$	$\geq 5\% < 15\%$	$\geq 0 < 5\%$	$< 0$
	Changes in the number or area of pests	$\leq -50\%$	$> -50\% \leq -20\%$	$> -20\% \leq 0$	$> 0$
	Changes in macrobenthic biomass	$\geq 10\%$	$\geq 5\% < 10\%$	$\geq 0 < 5\%$	$< 0$
	Dissolved oxygen in water (mg/L)	$\geq 6$	$\geq 5 < 6$	$\geq 4 < 5$	$< 4$
	Water body inorganic nitrogen ( $\mu\text{g/L}$ )	$\leq 200$	$> 200 \leq 300$	$> 300 \leq 400$	$> 400$
	Water active phosphate ( $\mu\text{g/L}$ )	$\leq 15$	$> 15 \leq 30$	$> 30 \leq 45$	$> 45$
	Sediment organic carbon	$\leq 2$	$> 2 \leq 3$	$> 3 \leq 4$	$> 4$
	Sediment sulfide ( $\mu\text{g/g}$ )	$\leq 300$	$> 300 \leq 500$	$> 500 \leq 600$	$> 600$
	Wave dissipative rate	$\geq 25\%$	$\geq 15\% < 25\%$	$\geq 5\% < 15\%$	$< 5\%$
Oyster reef ecological rehabilitation for hazard mitigation	Change in the area of oyster reef	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Change in the reef height	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in the density of live oysters	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$
	Changes in oyster	$\geq 50\%$	$\geq 10\% < 50\%$	$\geq 0 < 10\%$	$< 0$

Project type	Evaluation index		Assignment			
			80 (Significant improvement)	60 (Improvement)	40 (Basically no change)	20 (No improvement)
	recruitment					
	Changes in the number or area of pests		$\leq -50\%$	$> -50\% \sim \leq -20\%$	$> -20\% \sim \leq 0$	$> 0$
	Wave dissipative rate		$\geq 50\%$	$\geq 30\% \sim < 50\%$	$\geq 10\% \sim < 30\%$	$< 10\%$
Sandy coast ecological rehabilitation for hazard mitigation	Coast stability		Siltation	Stable	Micro-erosion/erosion	Strong erosion
	Beach topography		Developing beach berm and underwater sand dams, Erosion free scarp	Developing of beach berm, no underwater sand dam, Erosion free scarp	Developing beach berm, no underwater sand dam, Erosion scarps	Not developing beach berm and underwater sand bar, Erosion scarps
	Types of sediment		Fine sand	Medium-fine sand/medium sand	Coarse sand	Gravel
	Relative tidal range		$\geq 6$	$\geq 4 \sim < 6$	$\geq 3 \sim < 4$	$< 3$
	Biomass changes in the intertidal zone		$\geq 10\%$	$\geq 5\% \sim < 10\%$	$\geq 0 \sim < 5\%$	$< 0$
	Wave dissipative rate		$\geq 80\%$	$\geq 80\% \sim < 60\%$	$\geq 60\% \sim < 30\%$	$< 30\%$
Ecological sea dike reforming	Beach width(m)	Silty coast	$\geq 300$	$\geq 200 \sim < 300$	$\geq 100 \sim < 200$	$< 100$
		Sandy coast	$\geq 100$	$\geq 75 \sim < 100$	$\geq 50 \sim < 75$	$< 50$
	Change in the area of backshore vegetation		$\geq 10\%$	$\geq 5\% \sim < 10\%$	$\geq 0 \sim < 5\%$	$< 0$
	Change in the cover of backshore vegetation		$\geq 10\%$	$\geq 5\% \sim < 10\%$	$\geq 0 \sim < 5\%$	$< 0$
	Biomass changes in the intertidal zone		$\geq 10\%$	$\geq 5\% \sim < 10\%$	$\geq 0 \sim < 5\%$	$< 0$
	Wave dissipative rate		$\geq 80\%$	$\geq 80\% \sim < 60\%$	$\geq 60\% \sim < 40\%$	$< 40\%$

### 7.2.2.2 Comprehensive assessment method

After the completion of the project, the comprehensive evaluation index of the rehabilitation effect is calculated as shown in Eq. (3):

$$R = \frac{\sum_{i=1}^n Ri}{n} \quad \dots\dots\dots (3)$$

Where

$R$  is the comprehensive evaluation index of the rehabilitation effect.

$R_i$  is the  $i^{\text{th}}$  index of the assignment.

$n$  is the total number of evaluation indicators.

### 7.2.3 Classification of assessment results and supervision measures

According to the rehabilitation effect evaluation index  $R$ , coastal ecological rehabilitation for hazard mitigation projects is divided into four grades: excellent, good, qualified, and unqualified. The specific classification standards are shown in Table 7:

—— $R \geq 60$ , the evaluation level is that the rehabilitation effect of the project is very significant and the rehabilitation project is excellent.

—— $60 > R \geq 40$ , the evaluation level is that the rehabilitation effect is significant, and the rehabilitation project is good.



—— $40 > R \geq 30$ , the evaluation level is no obvious change, and the evaluation needs to be continued 1 to 2 times. If the R value of multiple evaluations is always greater than 30, the rehabilitation project is defined as qualified. If the R value is less than 30, the rehabilitation project is defined as unqualified.

—— $R < 30$ , the evaluation level is that the rehabilitation effect has not been achieved, and the rehabilitation project is a substandard project, which needs to be rectified, monitored, and evaluated again.

Table 7 — Effectiveness evaluation and supervision classification of coastal ecological rehabilitation projects

Evaluation index R of engineering rehabilitation effect	$\geq 60$	$\geq 40 - < 60$	$\geq 30 - < 40$	$< 30$
Evaluation level	The rehabilitation effect is very significant	Significant rehabilitation effect	No obvious change	The rehabilitation effect is not reached
	Excellent	Good	Qualified	Unqualified (need rectification)

## 8 Quality control

Quality control is implemented in accordance with the requirements of Section 8 of T/CAOE 21.1.

## 9 Results and archives

### 9.1 Results

Supervising and monitoring results include the report and data sets:

——The "Supervising and monitoring Report of Coastal Ecological Rehabilitation for Hazard Mitigation Project" is formed, and the report preparation outline and format are shown in Annex B.

——Tracking and monitoring survey data sets include survey datasheets, monitoring datasheets, photos, images, etc.

### 9.2 Archives

Filing archives is performed in accordance with the requirements of Section 9 of T/CAOE 21.1.

## Annex A (annex normative)

### Outline of the Implementation Plan for the Supervising and Monitoring of Coastal Ecological Rehabilitation for Hazard Mitigation Projects

#### A.1 Text format

##### A.1.1 Text specification

Text frame size A4 (210mm × 297mm)

##### A.1.2 Cover format

The first line is written in: ×××× sea area or province (No. 1 of font size, Song font, bold, centered).

The second line is written in: ×××× Ecological Disaster Mitigation and Rehabilitation Project supervising and monitoring Implementation Plan (No. 1 of font size, Song font, bold, centered).

The third line is written in: Full company name that prepares report (No.3 of font size, Song font, bold, centered).

The fourth line is written in: ××××year××month (small No.3 of font size, Song font, bold, centered).

The spacing between the above rows should be appropriate to keep the entire cover beautiful.

##### A.1.3 Inside cover content

The inside cover contents should be written in separately lines: the full name of the supervising and monitoring implementation unit (with official seal), the name of the person in charge of the project, the name of the person in charge of the technology, and the name of the person in charge of the sub-project, the full name of the organization that prepares the report (with official seal), the name of the person that prepares the report, reviewer name, address of the unit that prepares the report, mailing address, zip code, contact name, contact telephone number, and E-mail address, et al.

#### A.2 Outline for the preparation of the supervising and monitoring implementation plan for coastal ecological rehabilitation for hazard mitigation

The implementation plan for supervision and monitoring of the ×××× ecological rehabilitation for hazard mitigation project shall be organized in accordance with Table A.1. The relevant chapters can be appropriately added or deleted according to the characteristics of the survey area and the content of the survey.

Table A.1 — Outline for the preparation of the implementation plan for the supervising and monitoring of ×××× ecological rehabilitation for hazard mitigation projects

1 Task source
2 Project overview
2.1 Project goals
2.2 The construction content and approval status of the project
3 Tracking and monitoring
3.1 Monitoring area
3.2 Monitoring stations
3.3 Monitoring indicators and methods
3.4 Monitoring time and frequency

Outline for the preparation of the implementation plan for the supervising and monitoring of  
×××× ecological rehabilitation for hazard mitigation projects (Continued)

- |  |
|--|
| <ul style="list-style-type: none"><li>4 Ecological rehabilitation for hazard mitigation assessment<ul style="list-style-type: none"><li>4.1 Evaluation Index</li><li>4.2 Evaluation method</li></ul></li><li>5 Monitoring and evaluating personnel</li><li>6 Quality control</li><li>7 Security measures</li><li>8 Other</li></ul> |
|--|

## **Annex B**

### **(annex normative)**

## **Compilation outline of the supervising and monitoring report of coastal ecological rehabilitation for hazard mitigation projects**

### **B.1 Text format**

#### **B.1.1 Text specification**

Text frame size A4 (210mm × 297mm).

#### **B.1.2 Cover format**

The first line is written in: ×××× sea area or province (No. 1 Song Font, bold, centered).

The second line is written in: Supervising and Monitoring Report of ×××× Ecological Disaster Mitigation and Rehabilitation Project (No. 1 of font size, Song Font, bold, centered).

The third line is written in: Full company name that prepared the report (No.3 of font size, Song font, bold, centered).

The fourth line is written: in ××××year××month (small No.3 of font size, Song font, bold, centered).

The spacing between the above rows should be appropriate to keep the entire cover beautiful.

#### **B.1.3 Inside cover content**

The inside cover contents should be written in separately lines: the full name of the supervising and monitoring implementation unit (with official seal), the name of the person in charge of the project, the name of the person in charge of the technology, and the name of the person in charge of the sub-project, the full name of the organization that prepares the report (with official seal), the name of the person that prepared the report, reviewer name, address of the unit that prepares the report, mailing address, zip code, contact name, contact telephone number, and E-mail address, et al.

### **B.2 Outline of supervising and monitoring reports for coastal ecological rehabilitation for hazard mitigation projects**

The supervising and monitoring report of the ××××ecological rehabilitation for hazard mitigation project shall be prepared in accordance with Table B.1. The relevant chapters can be appropriately added or deleted according to the characteristics of the survey area and the content of the survey.

Table B.1 — Outline of supervising and monitoring reports for×××× coastal ecological rehabilitation for hazard mitigation project

1 General
1.1 Project source
1.2 The object of supervising and monitoring
2 Overview of the project background
2.1 Goals and indicators of development project
2.2 Construction content and approval status of the project
2.3 Status of the rehabilitation protection object before the project starts
2.4 Regional hazard prevention capabilities before the project starts
2.5 Ecological conditions of the surrounding coastal zone before the project

Outline of supervising and monitoring reports for×××× coastal ecological rehabilitation for  
hazard mitigation project (Continued)

- 3 The content of supervising and monitoring
  - 3.1 Monitoring area
  - 3.2 Monitoring station
  - 3.3 Monitoring indicators and methods
  - 3.4 Monitoring time and frequency
  - 3.5 Evaluation indicators and methods
- 4 Tracking and monitoring results
  - 4.1 Tracking and monitoring results of engineering rehabilitation objects
  - 4.2 Tracking and monitoring results of capabilities of engineering hazard mitigation
  - 4.3 Tracking and monitoring results of ecological impacts on surrounding coastal zones
  - 4.4 Tracking and monitoring results of engineering threat factors
- 5 Assessment results of ecological rehabilitation for hazard mitigation
  - 5.1 Evaluation results of engineering ecological rehabilitation
  - 5.2 Evaluation results of the ecological impact of the project on surrounding coastal zones
  - 5.3 Supervising level and measures of projects
- 6 Conclusions and recommendations

**Annex C**  
**(annex informative)**

**Tracking monitoring indicators and monitoring methods for coastal ecological rehabilitation for hazard mitigation projects**

**C.1 Tracking monitoring indicators and monitoring methods for mangrove ecological rehabilitation for hazard mitigation projects**

Tracking monitoring indicators should be selected according to Table C.1 and Table C.2, and each monitoring area can increase or decrease the monitoring items appropriately according to the actual situation and monitoring objectives in the mangrove ecological rehabilitation for hazard mitigation projects.

**Table C.1 — Tracking monitoring indicators and methods in the progress of mangroves ecological rehabilitation projects**

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Mangroves, Mangroves Vegetation*	Species, Seedling density, Planting survival rate	On-site monitoring	HY/T 081 T/CAOE 20.3 T/CAOE 20.2
		Area, Distribution	Remote sensing monitoring and on-site investigation	
	Pests	Species, Density	On-site monitoring	GB 17378.7 HY/T 080
		Area, Distribution	Remote sensing survey	
Ecology influences	Marine organisms*	Macrobenthos*	On-site monitoring	GB/T 12763.6 T/CAOE 20.3
		Benthic algae	On-site monitoring	GB 17378.7
	Water environment*	Water temperature, Salinity, Dissolved oxygen, pH value, Nitrite, Nitrate, Ammonium salt, Total phosphorus, Total nitrogen, etc.	On-site monitoring	GB 12763.2 GB 12763.4
	Deposition environment*	Particle size, Sulfide, Total organic carbon, Total phosphorus, Total nitrogen, Total salt content, Heavy metals, etc.	On-site monitoring	GB 12763.8 GB 17378.5 NY/T 1121.16
Threat factor	Natural factors	Storm surge, Typhoon, Extreme temperature, Alien species, Pests, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20.3
	Human activities	Catch the sea, Mariculture, Marine engineering, Land source sewage, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

**Table C.2 — Tracking and monitoring indicators and methods after the completion of the mangrove' s ecological rehabilitation project**

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Ecology effect	Mangroves vegetation*	Species, Quantity, Plant height, Breast diameter, Seedling proportion.	On-site monitoring	HY/T 081 T/CAOE 20.3

		Area, Distribution, Coverage, Forest belt width	Remote sensing survey	T/CAOE 20.2
	Pests	Species, Quantity	On-site monitoring	GB 17378.7
		Area, Distribution	Remote sensing survey	HY/T 080
	Biomes*	Macrobenthos*	On-site monitoring	GB/T 12763.6 T/CAOE 20.3
		Benthic algae	On-site monitoring	GB 17378.7
		Wetland birds	On-site monitoring combined with data collection	HJ 710.4
	Water environment	Water temperature, Salinity, Dissolved oxygen, pH value, Nitrite, Nitrate, Ammonium salt, Total phosphorus, Total nitrogen, etc.	On-site monitoring	GB 12763.2 GB 12763.4
Deposition environment	Deposition rate, Tidal flat elevation, Grain size, Sulfide, Total organic carbon, Total phosphorus, Total nitrogen, Total salt content, Heavy metals, etc.	On-site monitoring	GB/T 17501 GB 12763.8 GB 17378.5 NY/T 1121.16	
Disaster reduction effect	Disaster reduction function *	Effective wave height/Planting species, Planting belt width <sup>a</sup>	Sectional observation/On-site investigation	T/CAOE 21.2
Threat factor	Natural factors	Storm surge, Typhoon, Extreme temperature, Alien species, Pests, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20.3
	Human activities	Catch the sea, Mariculture, Marine engineering, Land source sewage, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				
<sup>a</sup> When the effective wave height is inconvenient to monitor, it can alternatively monitor indicators including the plant species, planting belt width, sandy beach or ecological sea dike width etc.				

## C.2 Tracking monitoring indicators and methods for salt marsh ecological rehabilitation for hazard mitigation projects

The tracking monitoring indicators of salt marshes ecological rehabilitation projects should be selected according to Table C.3 and Table C.4, and each monitoring area can increase or decrease the monitoring items according to the actual situation and monitoring objectives.

Table C.3 — The monitoring indicators and methods for the progress of the salt marshes ecological rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Salt marsh vegetation*	Salt marshes area, Distribution and width of vegetation zone	Remote sensing interpretation and on-site verification	T/CAOE 20.2
		Vegetation type, Density, Planting survival rate	On-site investigation	T/CAOE 20.4
	Pests	Species, Quantity	On-site monitoring	GB 17378.7 HY/T 080
		Area, Distribution	Remote sensing survey	
Ecology	Biomes*	Macrobenthos*	On-site monitoring	GB 12763.6

effect		Birds	On-site monitoring	HY/T 080
	Water environment*	Temperature, Salinity, Turbidity, Dissolved Oxygen, pH value, Total organic carbon, Nitrite, Nitrate, Ammonium salt, Active phosphate, etc.	On-site investigation	GB/T 12763.2 GB 17378.4 HY/T 147.1 GB/T 12763.4
	Deposition environment*	Particle size, Total salt content, pH value, Total organic carbon, Redox potential, Total nitrogen, Total phosphorus, etc.	On-site investigation	GB/T 12763.8 NY/T 1121.16 GB 17378.5
Threat factor	Natural factors	Storm surge, Typhoon, Sea-level change, Coastal erosion, Alien species, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20.4
	Human activities	Tidal flat aquaculture activities, Fisheries fishing, Coastal engineering, Land-source sewage discharge, Resource utilization (Such as sand mining, mining, oil extraction, etc.), Tourism development activities, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

Table C.4 —Tracking and monitoring indicators and methods after the completion of the salt marshes ecological rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Ecological effects	Salt marsh vegetation*	Salt marshes area, Distribution and width of vegetation zone	Remote sensing interpretation and on-site verification	T/CAOE 20.2
		Vegetation type, Density, Coverage, Average height, Biomass	Site investigation	T/CAOE 20.4
	Pests	Species, Quantity	On-site monitoring	GB 17378.7 HY/T 080
		Area, Distribution	Remote sensing survey	
	Biomes*	Macrobenthos*	On-site monitoring	GB 12763.6
		Birds	On-site monitoring	HY/T 080
	Water environment*	Temperature, Salinity, Turbidity, Dissolved oxygen, pH, Total organic carbon, Nitrite, Nitrate, Ammonium salt, Active phosphate, etc.	On-site investigation	GB/T 12763.2 GB 17378.4 HY/T 147.1 GB/T 12763.4
	Deposition environment*	Tidal flat elevation, Grain size, Total salt content, pH value, Total organic carbon, Redox potential, Total nitrogen, Total phosphorus, etc.	On-site investigation	GB/T 17501 GB/T 12763.8 NY/T 1121.16 GB 17378.5
Disaster reduction effect	Disaster reduction function*	Effective wave height/Planting species, Planting belt width	Sectional observation/site investigation	T/CAOE 21.3



Threat factor	Natural factors	Storm surge, Typhoon, Sea-level Change, Coastal erosion, Alien species, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20. 4
	Human activities	Tidal flat aquaculture activities, Fisheries fishing, Coastal engineering, Land-source sewage discharge, Resource utilization (Such as sand mining, mining, oil extraction, etc.), Tourism development activities, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

### C.3 The tracking and monitoring indicators and methods for coral reef ecological rehabilitation for hazard mitigation projects

The tracking monitoring indicators of coral reefs ecological rehabilitation projects should be selected according to Table C.5 and Table C.6, and each monitoring area can increase or decrease the monitoring items appropriately according to actual conditions and monitoring objectives.

Table C.5 — The tracking monitoring indicators and methods in the progress of coral reefs rehabilitation projects

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Scleractinian corals*	Types of living reef corals, Coverage rate, survival rate of transplantation planting	On-site investigation	T/CAOE 20.5
	Predator	Species, Quantity	On-site monitoring	
Ecological impact	Biomes*	Coral reefs fishes	On-site investigation	T/CAOE 20.5
		Macrobenthos		
		Large benthic algae		
	Water environment*	Water temperature, Transparency, Salinity, pH, Dissolved oxygen, Nitrite, Nitrate, Ammonium salt, Active phosphate, Total phosphorus, Total nitrogen, Suspended solids, etc.	On-site monitoring	GB 12763.2 GB 17378.3
	Deposition environment*	Granularity, Matrix, Sedimentation rate, Sediment coverage rate, etc.	On-site monitoring	GB 12763.8 T/CAOE 20.5
Threat factor	Natural factors	Typhoon, Extreme high or low temperature, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20.5
	Human activities	Coastal zone engineering, Dredging, Quarrying and quarrying, Tourism development, Sewage and Warm drainage, Fishery fishing, Aquaculture, Artificial facilities on water and seabed, Emergencies, Marine garbage, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project				

Monitoring items	Monitoring indicators	Monitoring/Analysis method	Guideline
needs and circumstances.			

Table C.6 — Tracking and monitoring indicators and methods after the completion of the coral reefs rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Ecological effects	Scleractinian corals*	Types of living reef corals, Coverage rate, Coral mortality, Hard coral recruitment, Coral bleaching status	On-site investigation	T/CAOE 20. 5
	Predator	Species, Quantity	On-site monitoring	
	Biomes*	Coral reefs fishes	On-site investigation	T/CAOE 20. 5
		Macrobenthos		
		Large benthic algae		
	Water environment	Water temperature, Transparency, Salinity, pH, Dissolved oxygen, Nitrite, Nitrate, Ammonium salt, Active phosphate, Total phosphorus, Total nitrogen, Suspended solids, etc.	On-site monitoring	GB 12763.2 GB 17378. 3
Deposition environment	Granularity, Matrix, Sedimentation rate, Sediment coverage rate, etc.	On-site monitoring	GB 12763.8 T/CAOE 20. 5	
Disaster reduction effect	Disaster reduction function*	Effective wave height/Planting species, Planting belt width	Sectional observation/ Site investigation	T/CAOE 21. 4
Threat factor	Natural factors	Typhoon, extremely high or low temperature, etc.	Data collection, field survey, social survey, etc.	T/CAOE 20. 5
	Human activities	Coastal zone engineering, Dredging, Quarrying and quarrying, Tourism development, Sewage, and warm drainage, Fishery fishing, aquaculture, Artificial facilities on water and seabed, Emergencies, Marine garbage, etc.		
NOTE: items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

#### C.4 Tracking monitoring indicators and methods for seagrass bed ecological rehabilitation for hazard mitigation project

The tracking and monitoring indicators of the seagrass bed ecological rehabilitation project should be selected according to Table C.7 and Table C.8, and each monitoring area can increase or decrease the monitoring items appropriately according to actual conditions and monitoring objectives.

Table C.7 — Tracking monitoring indicators and methods in the progress of the seagrass bed rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Seagrass bed*	Species, Area, Density, Coverage, Planting survival rate	On-site survey or aerial photography	T/CAOE 20.6

	Pests	Species, Quantity	On-site monitoring	GB 17378. 7 HY/T 080
		Area, Distribution	Remote sensing survey	
Ecological impact	Biomes*	Macrobenthos*	On-site investigation	T/CAOE 20. 6 GB/T 12763. 6
		Macroalgae*		
		Swimming animals		
		Roe larvae		
	Seawater environment*	Transparency, Water temperature, Salinity, Dissolved oxygen, Suspended matter, Nitrite, Nitrate, Ammonium salt, Active phosphate, etc.	On-site investigation	GB/T 17378. 4 GB/T 12763. 2 GB/T 12763. 4
	Deposition environment*	Particle size, Total organic carbon, Sulfide, Total phosphorus, Total nitrogen, etc.	On-site monitoring	GB 12763. 8 GB 17378. 5
Threat factor	Natural factors	Typhoon, Storm surge, biological invasion	Data collection, Field survey, social survey, etc.	T/CAOE 20. 6
	Human activities	Fishery fishing, Benthic organisms Harvesting, Mariculture, Marine engineering, Land source sewage, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

Table C.8 —Tracking and monitoring indicators and methods after the completion of the seagrass bed rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/analysis method	Guideline
Ecological effects	Seagrass bed*	Species, Area, Coverage, shoot density, Shoot height, Biomass	On-site survey or aerial photography	T/CAOE 20.6
	Pests	Species, Quantity	On-site monitoring	GB 17378.7 HY/T 080
		Area, Distribution	Remote sensing survey	
	Biomes*	Macrobenthos*	On-site investigation	T/CAOE 20.6 GB/T 12763.6
		Macroalgae*		
		Swimming animals		
		Roe larvae		
	Seawater environment*	Transparency, Water temperature, Salinity, Dissolved oxygen, Suspended matter, Nitrite, Nitrate, Ammonium salt, Active phosphate, etc.	On-site investigation	GB/T 17378.4 GB/T 12763.2 GB/T 12763.4
	Deposition environment*	Elevation, Particle size, Total organic carbon, Sulfide, Total phosphorus, Total nitrogen, etc.	On-site monitoring	GB/T 17501 GB 12763.8 GB 17378.5
Disaster reduction effect	Disaster reduction function*	Effective wave height/Planting species, Planting belt width	Sectional observation/ On-site investigation	T/CAOE 21.5
Threat factor	Natural factors	Typhoon, Storm surge, biological invasion	Data collection, Field survey, social survey, etc.	T/CAOE 20.6
	Human activities	Fishery fishing, Benthic organisms harvesting, Mariculture, Marine		

		engineering, Land source sewage, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

### C.5 Tracking monitoring indicators and methods for oyster reef ecological rehabilitation for hazard mitigation project

Tracking monitoring index of the oyster reef ecological rehabilitation project should be selected according to Table C.9 and Table C.10, and each monitoring area can appropriately increase or decrease the monitoring items according to the actual situation and monitoring objectives.

Table C.9 — The tracking monitoring indicators and methods in the progress of the oyster reef rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Oyster reef*	Oyster reef area, Height	Distance measuring wheel, Aerial photography, Sonar, etc.	T/CAOE 20. 7
	Live oysters*	Species, Density, Shell height, Biomass	On-site sampling	
	Predator	Species, Quantity	On-site investigation	GB 17378. 7 GB/T 12763. 6
Ecological impact	Biomes*	Macrobenthos	On-site investigation	GB/T 12763. 6
		Phytoplankton		
	Water environment*	Water temperature, Salinity, Flow rate, Dissolved oxygen, pH value, etc.	On-site investigation	GB/T 12763. 2 GB/T 12763. 4
	Deposition environment*	Substrate type, etc.	On-site monitoring	T/CAOE 20. 7
Threat factor	Natural factors	Predator, Competitor	Data collection, Field survey, social survey, etc.	T/CAOE 20. 7
	Human activities	Fishing, Breeding, Marine engineering, Land-based pollution, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

Table C.10 — Tracking and monitoring indicators and methods after the completion of the oyster reef rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Ecological effects	Oyster reef*	Oyster reef area, Height	Distance measuring wheel, Aerial photography, Sonar, etc.	T/CAOE 20.7
	Live oysters*	Species, Density, Replenishment amount, Living shell height, Biomass	On-site sampling	
	Predator	Species, Quantity	On-site investigation	GB 17378.7 GB/T 12763.6
	Biomes*	Macrobenthos	On-site investigation	GB/T 12763.6
		Phytoplankton		

	Water environment	Water temperature, Salinity, Flow rate, Dissolved oxygen, pH value, etc.	On-site investigation	GB/T 12763.2 GB/T 12763.4
	Deposition environment	Substrate type, etc.	On-site monitoring	T/CAOE 20.7
Disaster reduction effect	Disaster reduction function*	Effective wave height/Planting species, Planting belt width	Sectional observation/ On-site investigation	T/CAOE 21.6
Threat factor	Natural factors	Predator, Competitor	Data collection, Field survey, social survey, etc.	T/CAOE 20.7
	Human activities	Fishing, Breeding, Marine engineering, Land-based pollution, etc.		
NOTE: items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

#### C.6 Tracking and monitoring indicators and methods for sandy coast ecological rehabilitation for the hazard mitigation project

Tracking monitoring index of the sandy coast ecological rehabilitation project should be selected according to Table C.11 and Table C.12, and each monitoring area can increase or decrease the monitoring items according to the actual situation and monitoring objectives.

Table C.11 — The tracking monitoring indicators and methods in the progress of sandy coast rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/analysis method	Guideline
Engineering effect	Shoreline*	Shoreline length, Shoreline position	On-site investigation, Remote sensing monitoring	T/CAOE 20.8 GB/T 17501 GB/T 12763.8 GB/T 12763.10 HY/T 255
	Terrain*	Backshore, Foreshore, Inner shore profile topography	On-site investigation	
	Beach topography*	Beach berm, Erosion ridge, Sand ripple, Submarine bar of underwater sand dam, etc.	On-site investigation	
	Sediment*	Granularity	On-site investigation	
	Hydrodynamics	Waves, Ocean currents, Suspended sand, Tide level, Wind, Regional sea level	On-site investigation	
Ecological impact	Biomes*	Intertidal organisms*	On-site investigation	T/CAOE 20.8
		Backshore vegetation	On-site investigation	T/CAOE 20.8 LY/T 1820
	Water environment*	Water color, Water temperature, Transparency, Salinity, pH, Dissolved Oxygen, Petroleum, etc.	On-site investigation	GB/T 17378.3 GB/T 17378.4
	Deposition environment*	Petroleum, Sulfide, Total organic carbon, etc.	On-site monitoring	GB 17378.5
Threat factor	Natural factors	Typhoon, Storm surge, etc.	Data collection, Field survey, social survey, etc.	T/CAOE 20.8
	Human	Coastal structures, Marine garbage, etc.		

Monitoring items		Monitoring indicators	Monitoring/analysis method	Guideline
	activities	Harvesting and breeding, Artificial sand mining, Deforestation, Forest disasters, etc.		
NOTE: items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

Table C.12 — Tracking and monitoring indicators and methods after the completion of the sandy coastal rehabilitation project

Monitoring items		Monitoring indicators	Monitoring/analysis method	Guideline
Ecological effects	Shoreline*	Shoreline length, Shoreline position	On-site investigation, Remote sensing monitoring	T/CAOE 20.8 GB/T 17501 GB/T 12763.8 GB/T 12763.10 HY/T 255
	Terrain*	Backshore, Foreshore, Inner shore profile topography	On-site investigation	
	Beach topography*	Beach berm, Erosion ridge, Sand ripple, Submarine bar of underwater sand dam, etc.	On-site investigation	
	Sediment*	Granularity	On-site investigation	
	Hydrodynamics*	Waves, Ocean currents, Suspended sand, Tide level, Wind, Regional sea level	On-site investigation	
	Biomes*	Intertidal organisms*	On-site investigation	T/CAOE 20.8
		Backshore vegetation	On-site investigation	T/CAOE 20.8 LY/T 1820
	Water environment	Water color, Water temperature, Transparency, Salinity, pH, Dissolved oxygen, Petroleum, etc.	On-site investigation	GB/T 17378.3 GB/T 17378.4
Deposition environment	Petroleum, Sulfide, Total organic carbon, etc.	On-site monitoring	GB 17378.5	
Disaster reduction effect	Disaster reduction function*	The effective wave height/shore width of the inside and outside of the breaker zone <sup>a</sup>	Sectional observation/ Site investigation	T/CAOE 21.7
Threat factor	Natural factors	Typhoon, Storm surge, etc.	Data collection, Field survey, Social survey, etc.	T/CAOE 20.8
	Human activities	Coastal structures, Marine garbage, Harvesting and breeding, Artificial sand mining, Deforestation, Forest disasters, etc.		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

### C.7 Tracking and monitoring indicators and methods for construction of sea dike ecological sea dike reforming project

The tracking and monitoring indicators of the ecological sea dike reforming project of the ecological sea dike reforming project shall be selected according to the attached Table C.13 and Table C.14, and each monitoring area can increase or decrease the monitoring items appropriately

according to the actual situation and monitoring objectives.

Table C.13 — Tracking monitoring indicators and methods in the progress of ecological sea dike reforming projects

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Engineering effect	Vegetation*	Species, Density, Survival rate	On-site verification	LY/T 1820
	Beach stability*	Coastline location, Beach width, Sediment grain size	Remote sensing interpretation and on-site verification	HY/T 080 T/CAOE 20. 8
	Hydrodynamics	Waves, Ocean currents, Suspended sand, Tide level, Wind, Regional sea level	On-site investigation	HY/T 255
Ecological impact	Biomes*	Intertidal organisms*	On-site investigation	T/CAOE 20. 8
		Backshore vegetation	On-site investigation	T/CAOE 20. 8 LY/T 1820
	Water environment*	Water color, Water temperature, Transparency, Salinity, pH, Dissolved oxygen, Petroleum, etc.	On-site investigation	GB/T 17378. 3 GB/T 17378. 4
	Deposition environment*	Petroleum, Sulfide, Total organic carbon, etc.	On-site monitoring	GB 17378. 5
Threat factor	Natural factors	Storm surge, Typhoon, Coastal erosion, Sea ice, Alien species, etc.	Data collection, Field survey, social survey, etc.	T/CAOE 20. 8
	Human activities	Coastal structures		
NOTE items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				

Table C.14 — Tracking and monitoring indicators and methods after the completion of the ecological sea dike reforming project

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Ecological effects	Vegetation*	Species, Density, Survival rate	On-site verification	LY/T 1820
	Beach stability*	Coastline location, Beach width, Sediment grain size	Remote sensing interpretation and on-site verification	HY/T 080 T/CAOE 20.8
	Hydrodynamics *	Waves, Ocean currents, Suspended sand, Tide level, Wind, Regional sea level	On-site investigation	HY/T 255
	Biomes*	Intertidal organisms*	On-site investigation	T/CAOE 20.8
		Backshore vegetation	On-site investigation	T/CAOE 20.8 LY/T 1820
	Water environment	Water color, Water temperature, Transparency, Salinity, pH, Dissolved oxygen, Petroleum, etc.	On-site investigation	GB/T 17378.3 GB/T 17378.4
	Deposition environment	Petroleum, Sulfide, Total organic carbon, etc.	On-site monitoring	GB 17378.5

Monitoring items		Monitoring indicators	Monitoring/Analysis method	Guideline
Disaster reduction effect	Disaster reduction function*	Effective wave height/width of ecological sea dike	Sectional observation/ Site investigation	T/CAOE 21.7
Threat factor	Natural factors	Storm surge, Typhoon, Coastal erosion, Sea ice, Alien species, etc.	Data collection, Field survey, social survey, etc.	T/CAOE 20.8
	Human activities	Coastal structures		
NOTE: items marked * are indispensable index; other indicators can be electively tested according to project needs and circumstances.				