



# Social Organization Standard

T/CAOE 20.3-2020

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## Technical guideline for investigation and assessment of coastal ecosystem —

### Part 3:

### Mangroves

海岸带生态系统现状调查与评估技术导则 第3部分：红树林

*(English Translation)*

Issue date: 2020-05-06

Implementation date: 2020-05-06

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Issued by China Association of Oceanic Engineering



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## Foreword

The T/CAOE 20 *Technical guideline for investigation and assessment of coastal ecosystem* consists of the following ten parts:

- Part 1: General;*
- Part 2: Remote sensing identification and results verification of the coastal ecosystem;*
- Part 3: Mangroves;*
- Part 4: Salt marshes;*
- Part 5: Coral Reefs;*
- Part 6: Seagrass bed;*
- Part 7: Oyster Reef;*
- Part 8: Sandy Coast;*
- Part 9: Estuary;*
- Part 10: Bay.*

This is part 3 of T/CAOE 20, which is used together with Part 1.

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.*

This standard was prepared by *China Association of Oceanic Engineering.*

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# Technical guideline for investigation and assessment of coastal ecosystem —

## Part 3: Mangroves

### 1 Scope

This part of T/CAOE 20 specifies the working procedures, survey contents, survey methods, ecological status evaluation and other requirements for the survey and evaluation of the status of mangrove ecosystems.

This part is applicable to the investigation and assessment of coastal mangrove ecosystems.

### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. GB/T 12763.2 Specifications for oceanographic survey—Part 2: Marine hydrographic observation

GB/T 12763.4 *Specifications for oceanographic survey—Part 4: Survey of chemical parameters in sea water*

GB/T 12763.6 *Specifications for oceanographic survey—Part 6: Marine biological survey*

GB/T 12763.8 *Specifications for oceanographic survey—Part 8: Marine geology and geophysics survey*

GB/T 12763.9 *Specifications for oceanographic survey—Part 9: Guidelines for marine ecological survey*

GB 17378.5 *The specification for marine monitoring—Part 5: Sediment analysis*

GB 17378.7 *The specification for marine monitoring—Part 7: Ecological survey for offshore pollution and biological monitoring*

GB/T 17501 *Specification for marine engineering topographic surveying*

GB/T 30363 *Technical specification for forest vegetation monitoring*

HY/T 081 *Technical specification for eco-monitoring of mangrove ecosystems*

HJ 710.4 *Technical guidelines for biodiversity monitoring—birds*

NY/T 1121.16 *Soil Testing—Part 16: Method for determination of total water-soluble salt*

T/CAOE 20.1-2020 *Technical guideline for survey and evaluation of coastal ecosystem Part 1: General*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

#### 3.1

##### **mangrove**

Ligneous plants that grow in the intertidal zone of tropical and subtropical regions

#### 3.2

##### **mangroves; mangrove forest**

Tropical and subtropical coastal biological communities dominated by mangrove plants

#### 3.3

##### **aerial root**

Roots above the ground.

#### 4 General rules

##### 4.1 Working procedures

The working procedures are implemented in accordance with the requirements given in Chapter 5 of T/CAOE 20.1-2020.

##### 4.2 Quality control

Quality control is implemented in accordance with the requirements given in T/CAOE 20.1-2020, 4.3.

##### 4.3 Survey plan design

The survey plan is designed and compiled in accordance with the requirements given in of T/CAOE 20.1-2020, Chapter 6.

##### 4.4 Operation results

The results of the work are implemented in accordance with the requirements given in T/CAOE 20.1-2020, Chapter 9.

##### 4.5 Archiving of data and results

The archive of data and results should be implemented in accordance with the requirements given in T/CAOE 20.1-2020, Chapter 10.

#### 5 Survey contents

The survey of mangrove ecosystems includes mangrove vegetation, biological communities, environmental elements and threat factors. The survey contents, factors, and methods are shown in Table 1. Different survey elements may be selected according to the purpose of the survey and evaluation requirements. The instruments and materials employed for the mangrove ecosystem survey are shown in Annex I.

Table 1-Contents and methods of mangrove ecosystem survey

Survey contents	Survey elements	Survey approaches	Survey methods
Mangrove vegetation	Mangrove vegetation: Area, distribution, forest belt width, biological species, coverage, plant density, plant height, diameter at breast height (DBH), basal diameter, seedling density, sapling density,	Field survey  Remote	See 6.3

	litterfall yield, aerial root type, aerial root density, biomass	sensing (RS) survey	
Biological community	Benthic algae: Species, density, biomass	Field survey	See 6.4.1
	Macrobenthos: Species, density, biomass, crab burrow density		See 6.4.2
	Birds: Species, quantity		See 6.4.3
Environmental elements	Water environment: Water temperature, salinity, pH, dissolved oxygen (DO), ammonia, nitrate, nitrite, total nitrogen (TN), total phosphorus (TP)	Field survey	See 6.5.1
	Sedimentary environment: Tidal flat elevation, sedimentation rate, sediment grain size, organic carbon, sulfide, total salt content, total phosphorus, total nitrogen, heavy metals		See 6.5.2
Threaten factors	Natural factors: Typhoon, storm surge, extreme temperature, sea level change, harmful species	Data collection	See 6.6.1
	Anthropogenic factors: Beach comb in the mangroves (the number of sea catchers, operation methods, operation frequency), mariculture (type, area, impact categories), pollutant emissions (type, emissions, impact categories), ocean (coastal) engineering (development status, type, scale)	Field survey Social survey	See 6.6.2
<p>NOTE 1: The area, distribution, forest belt width and coverage are surveyed by RS, while field surveys are adopted for the other factors.</p> <p>NOTE 2: The DBH of trees with an obvious backbone should be surveyed. For trees without an obvious backbone and shrubs, the diameter at 30 cm above the ground should be surveyed.</p>			

## 6 Survey methods

### 6.1 Layout of sites

#### 6.1.1 Layout principles

The layout of survey sites shall conform to the following principles:

- Comprehensiveness: The stations shall be arranged reasonably, covering the entire survey area and fully reflecting the spatial heterogeneity of the mangrove ecosystem in the survey area.

- Representativeness: The stations shall include all representative plant species so that the survey results fully reflect the current status of mangroves.
- Fixation: Once determined, the locations of the stations shall remain unchanged for long-term monitoring and provide a basis for continuous management.

### 6.1.2 Layout methods

The following are the methods for determining site layouts:

- a) Comprehensively consider the distribution of mangrove vegetation in the survey area, water environment, sediment type and other factors to divide the survey into sections.
- b) In areas where the information on mangrove distribution is limited, line-of-zone separation methods are used to determine the species and distribution of mangrove vegetation. Record all mangrove species found in the area. The specific survey shall be carried out in accordance with GB/T 30363.
- c) According to factors such as mangrove vegetation, tidal flat elevation and development activities, each survey profile shall be arranged in a cross-shore direction perpendicular to the coastline. The number of survey sections is shown in Table 2.

Table 1-Requirements for the number of mangrove survey sections

Mangrove shoreline length/(km)	Number of sections
$\leq 0.3$	$\geq 1$
$>0.3 \sim \leq 2$	$\geq 2$
$>2$	1/km, $\geq 2$

- d) For each survey section, survey stations shall be arranged according to mangrove vegetation and tidal flat elevation. If the mangrove forest is a single species population in the area, no less than 3 stations shall be established for each survey section. If the mangrove forest includes multiple community types in the area, it is suggested to set up stations in each community type.
- e) At each survey station, no less than 3 permanently fixed mangrove vegetation quadrats shall be set up, and stakes shall be used to mark the four corners of the quadrats. Each stake must be marked with the section and quadrat number, and the latitude and longitude of the centre of the quadrat shall be recorded.
- f) The layout of biological communities and environmental element surveys shall be carried out simultaneously with the survey of vegetation communities. The setting of quadrats shall be implemented in accordance with GB/T 12763.9.

### 6.2 Survey frequency

The following are the survey frequency requirements:

- a) Mangrove vegetation, sedimentary environmental elements, and threat factors shall be surveyed at least once per year. Mangrove litterfall yield shall be surveyed monthly.
- b) The biological community and water environment elements shall be surveyed once every season in spring, summer, autumn and winter.
- c) The time when surveys are conducted in each season shall remain as similar as possible among the years, and the deviation of the survey time shall not exceed 15 days. The survey of water



environmental factors shall be carried out on the day of spring tide, and the survey of other factors shall be carried out on the day of neap tide.

### 6.3 Mangrove vegetation survey

The mangrove vegetation survey methods are as follows:

- a) The area, distribution, coverage and width of mangroves are surveyed by remote sensing, which are implemented in accordance with T/CAOE 20.1-2020 and HY/T 081.
- b) The forest belt width is the average forest belt width of each survey area, and the forest belt width is calculated according to formula (1):

$$W = \frac{A}{L} \dots\dots\dots (1)$$

where

- W The mangrove forest belt width, in metres (m);
- A The area of mangroves in the survey area, in square metres (m<sup>2</sup>);
- L The length of the mangrove shoreline in the survey section, in metres (m).
- c) Quadrat surveys are adopted to survey other elements of mangrove vegetation. Different vegetation types can be surveyed by different methods according to the following sample quadrats:
  - A 10 m×10 m sample quadrat shall be set for the survey of arbour-type vegetation: the species, number, height and diameter at breast height (DBH) of adult plants and sapling shall be investigated (plant height greater than 1 m, less than 2 m, diameter at breast height less than 5 cm). In the quadrat, a 1 m×1 m nested quadrat shall be established to record the species, number, plant height of seedlings (plant height less than or equal to 1m) and herbs, and aerial root types and number in the quadrat. The survey of relevant indicators is carried out in accordance with HY/T081. For the data report, see Table A.1.
  - For the shrub vegetation survey, a 5 m×5 m survey quadrat shall be set. A 2 m×2 m survey quadrat can be set if the vegetation is dense. The survey parameters and survey methods are the same as those for arbours.
- d) The litterfall yield shall be surveyed using a collection net. The mesh of the collection net shall be ≤2.0 mm, and the net opening shall be 1 m×1 m. The height of the installation shall be above the local highest tide line and below the vegetation canopy. An annual 12-month survey shall be conducted, and the litterfall in the collection net shall be retrieved monthly and then dried and weighed.
- e) The mangrove vegetation biomass survey is calculated using their respective standing tree biomass models, which are specifically implemented in accordance with GB/T 30363.

### 6.4 Biological community survey

#### 6.4.1 Benthic algae

Quantitative benthic algae samples shall be randomly collected from 25 cm×25 cm quadrats in each vegetation survey, and the specific implementation shall be in accordance with GB 17378.7.

#### 6.4.2 Macrobenthos

The following are the survey contents and methods for macrobenthos:

- The survey of species, density and biomass of macrobenthos is the same as that of benthic algae. A 25 cm×25 cm quadrat shall be randomly placed in each vegetation survey quadrat to investigate the microbenthic community. The specific implementation shall be in accordance with GB/T 12763.6. For the data report, see Table B.1.
- The survey of crab burrow density shall be synchronized with the macrobenthos survey, and 50 cm×50 cm quadrats shall be randomly set in each vegetation survey quadrat to record the number of crab burrow. If the crab holes are intensive, a 25 cm×25 cm square would be more suitable.

#### 6.4.3 Birds

Bird species and quantity shall be surveyed by the sample line method. The specific implementation is in accordance with HJ 710.4. For the survey records, see Table C.1.

### 6.5 Environmental elements survey

#### 6.5.1 Water environment

The following are the contents and methods for the water environment:

- The water temperature and salinity survey shall be carried out in accordance with the regulations of GB/T 12763.2. For the data report, see Table D.1.
- The survey of dissolved oxygen, pH value, nitrite, nitrate, ammonia salt, total phosphorus, and total nitrogen shall be carried out in accordance with the rules of GB/T 12763.4. For the data report, see Table D.1.

#### 6.5.2 Sedimentary environment

##### 6.5.2.1 sedimentation rate

The 4 standard stakes for the vegetation survey shall be employed as deposition rate survey piles, inserting the standard stakes vertically into the deposition until they are stable (at least 50 cm), numbering and recording the length of the standard stakes above the tidal flat surface. The annual change in the length of the stake above the surface of the tidal flat is the deposition rate.

##### 6.5.2.2 Tidal flat elevation

The tidal flat elevation survey shall be carried out in each sedimentary environment survey sample. The specific implementation is in accordance with GB/T 17501. The data are recorded as the local average sea level datum elevation.

##### 6.5.2.3 Sediment grain size and other chemical indicators

Surface Sediment samples (0 cm~10 cm) shall be collected from each sedimentary environment survey sample. The survey content and methods are as follows:

- The granularity survey shall be carried out in accordance with the rules of GB/T 12763.8. For the data report, see Table E.1.
- The survey of organic carbon, total nitrogen and total phosphorus shall be carried out in accordance with the rules of GB/T 12763.8. For the data report, see Table F.1.
- The sulfide survey shall be carried out in accordance with the rules of GB 17378.5. For the data report, see Table F.1.

- The total salt content survey shall be carried out in accordance with the rules of NY/T 1121. 16. For the data report, see Table F.1.
- Heavy metal survey shall be carried out according to GB 17378.5.

## 6.6 Threat factors survey

### 6.6.1 Natural factors

The contents and methods for the survey of natural factors are as follows:

- a. Information on the frequency, intensity, damage, disaster response and recovery of typhoons, storm surges and extreme temperatures, as well as changes in sea level, in the survey area shall be recorded through data collection. For the survey report, see Table G.1.
- b. Determine where the survey area is affected by pests while investigating and recording the species, distribution area and affected area of pests. For the survey report, see Table G.1.

### 6.6.2 Human factors

The contents and methods for the survey of human factors are as follows:

- a) In areas where there are beach comb activities, the beach comb operations shall be surveyed, photos and statistics of objects captured from the sea shall be taken, and information about the number of people driving to the sea in the mangrove forests, operation methods, operation frequency, operation area and impact on mangrove forests shall be collected. For the survey report, see Table G.1.
- b) In areas where mariculture exists, the types, coordinates, area, density, breeding methods and impacts on mangroves in the breeding areas shall be surveyed. For the survey report, see Table G.1.
- c) For survey areas where pollutants are discharged, pollutant discharge data shall be surveyed and collected, including pollution source distribution, main pollutant types, pollutant discharge methods, concentration, quantity into the sea, and impact on mangrove forests. For the survey report, see Table G.1.
- d) In the survey area where there are marine (coastal) projects, the location, quantity, scale, construction and operation of the project and the impact on the surrounding mangroves shall be surveyed. For the survey report, see Table G.1.

## 7 Ecological status evaluation

### 7.1 Evaluation parameters and weights

The evaluation of the ecological status of mangroves shall be conducted from 3 aspects: mangrove vegetation, biological community and environmental elements. For the details of the evaluation parameters and weights, see Table 3.

Table 3—Mangrove ecological status evaluation parameters and weights

Evaluation contents	Evaluation indicator	Weight
Mangroves	Total area	15
	Coverage	15
	Seedling proportion	10
	Forest belt width	10

	Mangrove species number	5
Biological community	Macrobenthic richness indicator	5
	Macrobenthic diversity index	5
	Number of bird species	5
Environmental elements	Water salinity	10
	Dissolved oxygen	5
	Deposition rate	10
	Sediment type	5

## 7.2 Frame of reference

The following are the selections and uses of the reference system:

- a) Collect historical data of the survey area, including routine monitoring, special surveys, and documentation to establish the frame of reference.
- b) The frame of reference shall employ representative data that reflect changes in ecosystems.
- c) When historical data are available, they can be used as a frame of reference for comprehensive evaluation.
- d) When there are some historical data, they can be used as a frame of reference for a single evaluation. Some indicators that lack historical data are only for status description.
- e) In the absence of historical data, only a description of the status quo is made and the results should serve as a reference for future assessments.

## 7.3 Evaluation methods

### 7.3.1 Mangrove vegetation

#### 7.3.1.1 Indicator assignment

Mangrove vegetation evaluation indicators, ratings and assignments are shown in Table 4.

Table 4—Mangrove vegetation evaluation indicators, ratings, and assignments

No.	Indicators	I (Stable)	II (Damaged)	III (Severely damaged)
1	Changes in total area	$\geq -3\%$	$\geq -10\% \sim < -3\%$	$< -10\%$
	Assignment	15	9	3
2	Changes in coverage	$\geq -3\%$	$\geq -10\% \sim < -3\%$	$< -10\%$
	Assignment	15	9	3
3	Planting survival rate Seedling proportion	$\geq 50\%$	$\geq 20\% \sim < 50\%$	$< 20\%$
	Assignment	10	6	2
4	Forest belt width (m)	$\geq 100$	$\geq 50 \sim < 100$	$< 50$
	Assignment	10	6	2
5	Changes in mangrove species number	$> -20\%$	$> -40\% \sim \leq -20\%$	$\leq -40\%$
	Assignment	5	3	1

NOTE 1: The width of the forest belt takes into account its effect of disaster reduction and shore protection.

NOTE 2: The number of mangrove species is the number of native species. The number of alien species is not included in the evaluation.

### 7.3.1.2 Calculation methods

Mangrove vegetation evaluation parameters shall be calculated according to the following methods:

a) Changes in the total area of mangrove forests are calculated by formula (2):

$$V_1 = \frac{A - A_0}{A_0} \times 100\% \quad \dots\dots\dots (2)$$

where

V1 Changes in the total area of mangroves, in percentage (%);

A The measured total area, in square metres (m<sup>2</sup>);

A0 The frame of the reference area, in square metres (m<sup>2</sup>).

b) Changes in mangrove coverage are calculated by formula (3):

$$V_2 = \frac{C - C_0}{C_0} \times 100\% \quad \dots\dots\dots (3)$$

where

V2 Changes in mangrove coverage, in percentage (%);

C The measured coverage, in percentage (%);

C0 The frame of reference coverage, in percentage (%).

c) The seedling proportion is calculated by formula (4):

$$V_3 = \frac{\sum_{i=1}^N Sd_i}{N} \quad \dots\dots\dots (4)$$

where

V3 The average seedling proportion in mangroves, in percentage (%);

Sdi The seedling proportion in sample i, in percentage (%);

N The total number of quadrats for the evaluation area.

d) The forest belt widths are calculated by formula (5):

$$V_4 = \frac{\sum_{i=1}^N W_i}{N} \quad \dots\dots\dots (5)$$

where

V4 Average forest belt width, in metres (m);

Wi Average forest belt width for survey section i, in metres (m);

N Total number of sections in the evaluation area.

e) Changes in mangrove species number are calculated by formula (6):

$$V_5 = \frac{S_p - S_{p0}}{S_{p0}} \times 100\% \quad \dots\dots\dots (6)$$

where

V5 Changes in mangrove species number, in percentages (%);

Sp The total mangrove species number in the survey;

Sp0 The mangrove species number in the frame of reference.

f) The mangrove vegetation status evaluation indicator is calculated by formula (7):

$$I_V = \sum_{i=1}^5 I_{Vi} \quad \dots\dots\dots (7)$$

where

$I_V$  Mangrove vegetation status evaluation index;

$I_{Vi}$  The assignment of the mangrove vegetation evaluation metrics for  $i$  (Table 4);

When  $43 < I_V \leq 55$ , mangrove vegetation is stable; when  $31 < I_V \leq 43$ , mangrove vegetation is damaged; and when  $11 \leq I_V \leq 31$ , mangrove vegetation is severely damaged.

### 7.3.2 Biological community

#### 7.3.2.1 Parameter assignment

For biological community evaluation parameters, ratings and assignments, see Table 5.

Table 5-Biological community evaluation parameters, ratings, and assignments

No.	Parameters	I (Stable)	II (Damaged)	III (Severely damaged)
1	Macrobenthic richness index	$\geq 2.5$	$\geq 1 \sim < 2.5$	$< 1$
	Assignment	5	3	1
2	Macrobenthic diversity index	$\geq 2.0$	$\geq 1 \sim < 2.0$	$< 1$
	Assignment	5	3	1
3	Bird species number	$\geq 65$	$\geq 30 \sim < 65$	$< 30$
	Assignment	5	3	1

#### 7.3.2.2 Calculation methods

Biological community evaluations shall be calculated as follows:

a) Macrobenthic richness index is calculated by formula (8):

$$B_1 = \frac{\sum_{i=1}^N d_i}{N} \quad \dots\dots\dots (8)$$

where

$B_1$  The average of the macrobenthic richness index;

$d_i$  The macrobenthic richness index for sample  $i$ . The calculation method is in formula H.1 of Annex table H;

$N$  The total number of quadrats for the evaluation area.

b) Macrobenthic diversity index is calculated by formula (9):

$$B_2 = \frac{\sum_{i=1}^N H_i}{N} \quad \dots\dots\dots (9)$$

where

$B_2$  The average of the macrobenthic diversity index;

$H_i$  The macrobenthic diversity index for sample  $i$ . The calculation method is in formula H.2 of Annex table H;

$N$  The total number of quadrats for the evaluation area.

c) The number of bird species is calculated by formula (10):

$$B_3 = \frac{\sum_{i=1}^N S d_i}{N} \quad \dots\dots\dots (10)$$

where

B3 The average number of bird species;

S<sub>di</sub> The number of bird species for the line transect i;

N The number of birds over the full survey line transect in the evaluation area.

d) The biological community status index is calculated by formula (11):

$$I_B = \sum_{i=1}^3 I_{Bi} \quad \dots\dots\dots (11)$$

where

IB Biological community status index;

I<sub>Bi</sub> The assignment of the biological community evaluation metrics for i (Table 4);

When  $11 < IB \leq 15$ , the biological community is stable; when  $7 < IB \leq 11$ , the biological community is damaged; and when  $3 \leq IB \leq 7$ , the biological community is severely damaged.

### 7.3.3 Environmental elements

#### 7.3.3.1 Parameter assignment

For environmental evaluation parameters, ratings and assignments, see Table 6.

Table 6-Environmental evaluation parameters, ratings, and assignments

No.	Parameters	I (Appropriate)	II (Moderately appropriate)	III (Inappropriate)
1	Water salinity	$\geq 5 \sim < 25$	$< 5$ or $\geq 25 \sim \leq 30$	$> 30$
	Assignment	10	6	2
2	Dissolved oxygen mg/L	$\geq 5$	$\geq 3 \sim < 5$	$< 3$
	Assignment	5	3	1
3	Deposition rate mm/a	$\geq 0 \sim \leq 20$	$> 20 \sim \leq 60$	$> 60$ or $< 0$
	Assignment	10	6	2
4	Sediment type	Clay	Silt	Sand
	Assignment	5	3	1

#### 7.3.3.2 Calculation methods

Environmental element evaluations are calculated as follows:

a) Water salinity indicator is calculated by formula (12):

$$E_1 = \frac{\sum_{i=1}^n S_{n_i}}{n} \quad \dots\dots\dots (12)$$

where

E<sub>1</sub> The average of water salinity;

S<sub>ni</sub> The annual maximum value of water salinity at station i;

n The number of stations in the evaluation area.

b) The dissolved oxygen indicator is calculated by formula (13):

$$E_2 = \frac{\sum_{i=1}^n D_{o_i}}{n} \quad \dots\dots\dots (13)$$

where

E2 The average dissolved oxygen of the water, in milligrams per litre (mg/L);

Doi The average dissolved oxygen for station i, in milligrams per litre (mg/L);

n The number of stations in the evaluation area.

c) The deposition rate indicator is calculated by formula (14):

$$E_3 = \frac{\sum_{i=1}^N Sr_i}{N} \dots\dots\dots (14)$$

where

E3 The average deposition rate, in millimetres per year (mm/a);

Sri The average deposition rate for station i, in millimetres per year (mm/a);

N The total number of quadrats for the evaluation area.

d) The sediment type indicator is calculated by formula (15):

$$E_4 = \frac{\sum_{i=1}^N Sf_i}{N} \dots\dots\dots (15)$$

where

E4 The assignment to sedimentary type parameters;

Sfi The assignment to sedimentary type for quadrat i (Table 6);

N The total number of samples for the evaluation area.

e) The environmental condition index is calculated by formula (16):

$$I_E = \sum_{i=1}^4 I_{Ei} \dots\dots\dots (16)$$

where

IE Environmental condition index;

IEi The assignment of the parameters for i (Table 6);

When  $22 < IE \leq 30$ , the environmental conditions are appropriate, when  $14 < IE \leq 22$ , the environmental conditions are moderately appropriate; when  $6 \leq IE \leq 14$ , the environmental conditions are inappropriate.

#### 7.3.4 Comprehensive evaluation of the ecological status of mangroves

The comprehensive evaluation of the ecological status of mangroves is calculated by formula (17):

$$I_M = I_V + I_B + I_E \dots\dots\dots (17)$$

where

IM Comprehensive mangrove ecological status index;

IV Mangrove vegetation status evaluation index;

IB Biological community status index;

IE Environmental condition index.

When  $IM > 76$ , the ecological condition of mangroves is stable, and the evaluation is class I.

When  $52 < IM \leq 76$ , the ecological condition of mangroves is damaged, and the evaluation is class II. When  $IM \leq 52$ , the ecological condition of mangroves is severely damaged, and the evaluation is class III.



The survey results shall be combined with the results of the above comprehensive evaluation of the ecological status of mangroves and other elements, such as threat factors, which are not included in the above quantitative evaluation. Then, the internal causes and external driving factors of changes in mangrove ecological status shall be comprehensively analyzed, and corresponding management measures shall be proposed (Table 7).

Table 7-Classification description and management measures of evaluation results of mangrove ecosystem status

Classification	Description	Management measures
I	The ecosystem is stable: Mangrove vegetation, biological community and environmental elements are stable and self-sustaining.	Continuous tracking and monitoring, scientific management
II	The ecosystem is damaged: Mangrove vegetation, biological community and environmental elements. Self-resilience is decline but can maintain basic structures.	Strengthen ecological management, control threat factors, and promote the natural restoration of ecosystems
III	Ecosystems have been severely damaged: Mangrove vegetation, biological community and environmental elements have been severely damaged. It is difficult to maintain basic structures, and self-recovery capacity has significantly decreased.	Strengthen ecological management, control threat factors, and propose artificial restoration measures to improve the state of ecosystems

**Annex A**  
**(annex normative)**  
**Basic Information on Mangrove Vegetation Community Survey**

Table A.1—provides the basic information for mangrove vegetation community surveys.

Table A.1-Basic information for mangrove vegetation community surveys

Survey date:

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Section NO.	Station NO.	Quadrat NO.	Quadrat Centre:	Longitude:	Latitude:
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[illegible]

Investigator:

Recorder :

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Proof reader:

**Annex B**  
**(annex normative)**  
**Survey Report of Mangrove Macrobenthos**

Table B.1—provides a report of survey data on macrobenthos in mangroves.

Table B.1—Survey report of mangrove macrobenthos

Survey date:

Page: of

Section NO.

Station NO.

Quadrat NO.

Quadrat Centre:

Longitude:

Latitude:

[illegible]

Investigator:

Recorder :

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Proof reader:

**Annex C**  
**(annex normative)**  
**Survey Record of Mangrove Birds**

Table C.1-gives a sheet for mangrove bird surveys.

Table C.1-Survey record for mangrove birds

Survey date			Weather	
Sample line number			Line transect length	
Survey area			Habitat type	
Latitude and longitude of the starting point			Start time	
Latitude and longitude of the end point			End time	
Type of human disturbance			Intensity of human disturbance	
Note				
Chinese name	Latin name	The vertical distance m from the line transect	Total number of individuals	Group label

Investigator:

Recorder:

Proof reader:

**Annex D**  
**(annex normative)**  
**Survey Report of Mangrove Water Environment**

Table D.1—provides a report of the mangrove water environment survey data.

Table D.1—Survey report of the mangrove water environment

Survey date:

Page: of

Section Number	Sample quadrat number	Longitude	Latitude	Temperature °C	Salinity	pH	Dissolved oxygen mg/L	Nitrate-nitrogen mg/L	Nitrite-nitrogen mg/L	Ammonia-nitrogen mg/L	Total nitrogen mg/L	Total phosphorus mg/L

Investigator:

Recorder:

Proof reader:

**Annex E**  
**(annex normative)**  
**Report of Mangrove Sediment Grain Size**

Table E.1-provides a report of mangrove sediment granularity data.

Table E.1-Report of mangrove sediment grain size

Survey date:

Page: of

[illegible]

Investigator:

Recorder :

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Proof reader:

**Annex F**  
(annex normative)  
**Survey Report of Mangrove Deposition Environment**

Table F.1-provides a report of the mangrove sedimentary environmental survey data.

Table F.1-Survey report of mangrove deposition environment

Survey date:

Page: of

[illegible]

Investigator:

Recorder :

Proofreader:

**Annex G**  
**(annex normative)**  
**Survey Report of Mangrove Threat Factors**

Table G.1—provides the mangrove threat factor survey report.

Table G.1—Survey report of mangrove threat factors

Survey Area: \_\_\_\_\_ Mangrove Area: \_\_\_\_\_ Survey Date: \_\_\_\_\_ Page: \_\_\_\_\_ of \_\_\_\_\_  
 Methods ☐ Access data ☐ Consult experts ☐ Field survey ☐ Questionnaire ☐ Other methods

Threat factors	Description of the situation	The level of threat
Natural disasters.	Description: Number of occurrences, intensity, damage, disaster management and recovery, etc.  Photo No. :	
Harmful organisms	Description: Species of organisms, distribution areas, affected areas, etc.  Photo No. :	
Fishing activity	Description: Information such as number of people fishing, mode of operation, frequency of operation, area of operation and impact on mangroves.  Photo No. :	
Marine aquaculture	Description: Species, coordinates, area and density of aquaculture, aquaculture methods and effects on mangrove forests, etc.  Photo No. :	
Pollutant emissions	Description: Distribution of pollution sources, types of major pollutants, sewage discharge methods, concentrations, amount of sea entry and effects on mangrove forests  Photo No. :	
Marine (coastal) engineering	Description: Location, quantity, scale, construction and operation of the engineering and its impact on the surrounding mangroves  Photo No. :	

Investigator: \_\_\_\_\_

Recorder: \_\_\_\_\_

Proof reader: \_\_\_\_\_

**NOTES:**

1. The survey method may be selected or multi method may be selected according to the actual situation to list the specific threat factors to investigate mangrove forests.
2. Describe the details of each threat factor and include as much information as possible, such as typhoon time, wind force, and impact range, before and after the typhoon for comparison



of mangroves. The results of the field survey shall be submitted at the same time as the photograph or photo number of the evidence, and the source shall be indicated in the references.

3. Natural disasters include typhoons, storm surges, extreme temperatures and sea level changes.

4. Harmful organisms include invasive organisms (e.g., *Spartina alterniflora* Loisel.), attached organisms (e.g., *Balanus*), pests and plant diseases.

5. The lowest threat level is 1 point, and the highest level is 10 points. Each threat factor shall be scored separately based on circumstances or expert advice.

## Annex H

### (annex informative)

### Biodiversity index calculation methods

#### H.1 Richness Margalef Index

The richness Margalef Index is calculated by Formula (H.1):

$$d = \frac{S-1}{\ln N} \dots\dots\dots (H.1)$$

where

- d Species richness index;
- S The total number of species in the sample;
- N The total number of individual organisms in the sample.

#### H.2 Species Diversity Index (Shannon-Weiner Index)

The species diversity index is calculated by formula (H.2):

$$H = -\sum \left( \frac{N_i}{N} \right) \ln \left( \frac{N_i}{N} \right) \dots\dots\dots (H.2)$$

where

- H Species diversity index;
- N<sub>i</sub> The number of species i in the sample per unit area;
- N The total number of benthic animals collected per unit area sample.

**Annex I**  
**(annex informative)**  
**Instruments and materials required for mangrove ecosystem surveys**

**I.1 Instruments and materials required for mangrove ecosystem surveys**

The instruments and materials required for mangrove ecosystem surveys are as follows:

- Handheld Global Positioning System
- 50 m tape measure
- 2 m tape measure
- Stakes or other permanent site markers
- Printed field record sheet
- Pencil
- Marker
- Shovel
- Salimeter
- Sample bag
- Sample bottle
- Quadrat box
- Digital camera
- Full-colour band HRV satellite data
- GIS software platform
- Telescopes
- Magnifier
- Marine chart
- Personal protection supplies for outdoors