



Social Organization Standard

T/CAOE 20.10-2020

Technical guideline for investigation and assessment of coastal ecosystem —

Part 10:

Bay

海岸带生态系统现状调查与评估技术导则 第10部分：海湾

(English Translation)

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Foreword

The T/CAOE 20-2020 *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 10 of the T/CAOE 20.

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 Ocean Engineering Consulting Association*.

This part was drafted by *North China Sea Offshore Engineering Survey Institute of State Oceanic Administration, National Marine Hazard Mitigation Service*.

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Technical guideline for investigation and assessment of coastal ecosystem —

Part 10: Bay

1 Scope

This part of T/CAOE 20 defines the general requirements, contents, methods, and ecological status assessment of the bay ecosystem.

This part is applicable to the bay ecosystem status survey and assessment.

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 version of the referenced document (including any amendments) applies.

GB/T 12343.1 *National basic scale map compilation specification Part 1: 1:25 000, 1:50 000, 1:100 000 Topographic map compilation specification.*

GB/T12763.2 *Marine survey specification Part 2: Marine hydrographic observation*

GB/T12763.6 *Marine survey specification Part 6: Marine biological survey*

GB/T12763.8 *Marine survey specification Part 8: Marine geological and geophysical survey specification*

GB17378.4 *Marine monitoring specification Part 4: Water analysis*

GB17378.5 *Marine monitoring specification Part 5: Sediment analysis*

HY/T 084-2005 *Bay ecological monitoring technical specifications*

HJ 710.4 *Technical guideline for biodiversity observation for birds*

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

T/CAOE 20.3 *Technical guideline for investigation and assessment of coastal ecosystem Part 3: Mangrove*

T/CAOE 20.4 *Technical guideline for investigation and assessment of coastal ecosystem Part 4: Salt Marsh*

T/CAOE 20.5 *Technical guideline for investigation and assessment of coastal ecosystem Part 5: Coral Reefs*

T/CAOE 20.6 *Technical guideline for investigation and assessment of coastal ecosystem Part 6: Seagrass Bed*

T/CAOE 20.7 *Technical guideline for investigation and assessment of coastal ecosystem Part 7: Oyster Reefs*

T/CAOE 20.8 *Technical guideline for investigation and assessment of coastal ecosystem Part 8: Sandy Coast*

T/CAOE 20.9 *Technical guideline for investigation and assessment of coastal ecosystem Part 9: Estuary*

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

bay

the water area with obvious curve concaves into land, having an area greater than or equal to the semicircle calculated by the width of the bay mouth as the diameter. The line between the two corresponding headlands of the bay mouth is the boundary between the bay and the adjacent sea.

3.2

bay ecosystem

the organisms and the semi-enclosed environment in bay constitute a unified natural whole.

3.3

tidal-flat wetland

the tidal zone between high and low tidal levels during spring tides.

4 General regulations

4.1 Working procedure

The working procedure is in accordance with the requirement of Chapter 5 of T/CAOE 20.1-2020.

4.2 Quality control

Quality control is in accordance with requirement of Section 4.3 in T/CAOE 20.1-2020.

4.3 Investigation and evaluation report preparation

The investigation and evaluation report outline is in accordance with the requirement of Section 9.1 in T/CAOE 20.1-2020.

4.4 Achievement archiving

The achievement archiving is in accordance with the requirement of Chapter 10 in T/CAOE 20.1-2020.

5 Status survey

5.1 Station layout

The basic principles of station layout are: full coverage, highlight representative, and general consideration. The station should be evenly distributed and cover the entire survey and assessment area. The survey area should consider the actual situation of the bay and the historical survey stations, if necessary, cover the entire bay.

According to the morphology, topography and hydrodynamics of the bay, stations should be arranged in the nearshore area (including the estuary), the middle part of the bay and the mouth of the bay. The station layout should consider estuaries, marine protected area, important fishery area and sewage dumping areas. In addition, the stations should be evenly arranged as far as possible. Linear and network layout can be adopted to determine the distribution trend of survey elements. The confirmed station layout should not be changed and remain unchanged in different cruises. Generally, the number of biological and sediment stations should be over 60% of the water stations.

5.2 Survey frequency

Morphological and hydrodynamic evaluation is mainly based on historic data collection, and one survey can be carried out if necessary. The survey of mangrove, salt marsh and other ecosystems in bay can be conducted once a year, and the survey time should be arranged from May to August. The investigation on biology and water elements should be carried out at least twice a year in the dry and wet seasons, or the mature and non-mature periods of the main biological objects, respectively. The survey frequency and period of birds and other wild animals should be determined according to the living habits of the objects.

5.3 Status survey content

The status survey of bay ecosystem includes the habitat, the biology and the threat factors. The survey results of each ecosystem and tidal-flat wetland in bay should be filled in Annex A. The survey results of shoreline in bay ecosystem habitats should be filled in Annex B. The reclamation area in threat factor survey should be filled in Annex C. The survey elements can be adjusted according to the characteristics of the bay, and meanwhile the historical missing elements can

be supplemented for the subsequent assessment. The status survey elements of the bay ecosystem are shown in Table 1.

Table 1—The elements of the bay ecosystem status survey

Survey content	Survey items	Elements
Bay environment	Hydrodynamics	Current
	Morphology	Type and length of natural shoreline, tidal-flat wetland and reclamation area
	Sediment	Sediment type, particle size, organic carbon, sulfide
	Water	Transparency, salinity, dissolved oxygen, inorganic nitrogen, active phosphate
Bay biology	Biology	Chlorophyll a, phytoplankton, zooplankton, macrobenthos, intertidal organisms, swimming animals, fish eggs and larvae, wildlife species in tidal-flat wetland
Threat factors	Marine development activities	Reclamation area, artificial shoreline length, aquaculture area
	Natural disaster status	Accumulated red-tide area
Note 1: The common survey indicators and survey frequency mentioned in both this table and Table 2 in HY/T 084-2005 are in accordance with the requirement of Section 4.1.2.2 in HY/T 084-2005.		
Note 2: The wildlife in tidal-flat wetlands include birds, amphibians, reptiles and mammals.		
Note 3: The aquaculture area here refers to the culture area enclosed by non-permeable structures.		

5.4 Sampling and analysis methods

The analysis methods of investigation elements are as shown in Table 2.

Table 2 Survey element observation/analysis methods

Items	Elements	Types	Standards
Hydrodynamics	Current	Fixed point or cruise measurement	GB/T 12763.2
Morphology	Tidal-flat wetland area	Remote sensing interpretation, field verification	GB/T 12343.1
	Reclamation area		
	Type and length of shoreline		
Sediment	Type, granularity	Field measurement	GB/T12763.8
	Organic carbon		GB 17378.5
	Sulfide		GB 17378.5
Water	Transparency	Field measurement	GB 17378.4
	Salinity		GB/T 12763.2
	Chemical oxygen demand		GB/T 12763.4
	Inorganic nitrogen		GB/T 12763.4
	Active phosphate		GB/T 12763.4
Biology	Chlorophyll a	Field measurement	GB/T 12763.6
	Phytoplankton		GB/T 12763.6
	Zooplankton		GB/T 12763.6
	Macrobenthos		GB/T 12763.6
	Intertidal organisms		GB/T 12763.6
	Swimming animals		GB/T 12763.6
	Fish eggs and larvae		GB/T 12763.6
	Birds	Field measurement, data collection	HJ 710.4

	Amphibians, reptiles, and beasts	Data collection, expert advice	
Marine development activities	Aquaculture area	Remote sensing interpretation, field measurement, data collection	
Natural disaster status	Accumulated red-tide area	Field measurement or data collection	

6 Ecosystem assessment

6.1 Evaluation indicators

The assessment categories include the bay habitat, biology and ecosystem stresses, and the corresponding assessment indicators for each category are given as follows:

- The assessment of mangrove, salt marsh, coral reefs and other ecosystems involved in the bay habitat is carried out in accordance with Table 3, and the assessment conclusions are cited in this section.
- Bio-assessment indicators are shown in Table 4.
- Indicators of ecosystem stress assessment: artificial shoreline length, reclamation area, and accumulated red-tide area. Qualitative analysis of sea level rise, green tide, storm surge and alien species invasion can be carried out if required.

Table 3 – Evaluation performance standard for habitat assessment

Assessment category	Evaluation performance standard
Mangrove	T/CAOE 20.3
Salt marsh	T/CAOE 20.4
Coral reefs	T/CAOE 20.5
Seaweed bed	T/CAOE 20.6
Oyster reefs	T/CAOE 20.7
Sandy coast	T/CAOE 20.8
Estuary	T/CAOE 20.9

Table 4 – Status assessment index of the bay ecosystem

Assessment category	Assessment content
Bay habitat	Tidal-flat area
	Tidal prism
	Organic carbon, sulfide
	Eutrophication level
	Primary productivity
	Mangrove, salt marsh, coral reefs, seagrass bed, oyster reefs, sandy coast, estuary
Bay biology	Shannon-wiener index
	Swimming animal density
	Density of fish eggs and larvae
	Number of biology species in bay
Ecosystem stress	Reclamation area, artificial shoreline length, aquaculture area, accumulated red-tide area

6.2 Evaluation methods

6.2.1 Reference system

Determining principle of benchmark includes:

- a) collecting the historical data of the investigation area, including routine monitoring, special investigation, literature data, etc. to establish a reference system;
- b) adopting representative data relating to changes of the ecosystem for the reference system;
- c) taking the historical data as the reference system of comprehensive evaluation if complete historical data available.
- d) taking the historical data as the reference system of individual evaluation if only some historical data available;
- e) describing the current status and taking the results as the reference system for future evaluation if no historical data available.

6.2.2 Evaluation methods

6.2.2.1 Evaluation index and classification

The ecological status assessment of the bay ecosystem includes three types of indicators, and the weights of each indicator are given as follows:

- Bay habitat 40
- Biology 40
- Ecosystem pressure 20

6.2.2.2 Habitat

Habitat assessment is calculated using the following method:

- a) Tidal-flat area reduction is calculated as:

$$A_t = \left| \frac{A - A_0}{A_0} \right| \times 100\% \quad \dots\dots\dots (1)$$

where

- A_t ——the reduced tidal-flat area;
- A ——the tidal-flat area in the evaluation year with the unit of square kilometer (km^2);
- A_0 ——the benchmark tidal-flat area in the reference system with the unit of square kilometer (km^2).

Table 5 – Evaluation index and valuation of bay ecosystem

Evaluation index	I	II	III
Reduction of tidal-flat area	$\leq 5\%$	$> 5\% \sim \leq 10\%$	$> 10\%$
Value	40	25	10
Note: The increase in area over the base year is assigned 40.			

- b) Tidal prism

Tidal prism index is calculated based on MIKE21 FM model as (2):

$$C_t = \left| \frac{C - C_0}{C_0} \right| \times 100\% \quad \dots\dots\dots (2)$$

where

- C_t ——tidal prism index;
- C ——tidal prism in the evaluation year with the unit of cubic meter (m^3);
- C_0 ——tidal prism in the reference system with the unit of cubic meter (m^3).

Table 6 – Evaluation index and valuation of tidal prism in bay

Index	I	II	III
Reduction of tidal prism	$\leq 5\%$	$> 5\% \sim \leq 10\%$	$> 10\%$
Value	40	25	10
Note: The increase in tidal prism over the base year is assigned 40			

Tidal prism is calculated as:

$$C = \frac{S_1 + S_2}{2} \times H \quad \dots\dots\dots (3)$$

where

C —tidal prism;

S_1 —water area at spring high tide with the unit of square meter (m^2);

S_2 —water area at spring low tide with the unit of square meter (m^2);

H —the corresponding tidal range with the unit of meter (m).

c) Sediment

The index is averaged on individual index of organic carbon and sulfide at each station based on Table 7.

Then the index at each station is averaged as the final result.

Table 7 – Evaluation index and valuation of sediment component in bay

Index	I	II	III
Organic carbon (%)	≤ 2.0	$> 2.0 \sim \leq 3.0$	> 3.0
Sulfide ($\mu g/g$)	≤ 300	$> 300 \sim \leq 500$	> 500
Value	40	25	10

d) Eutrophication level

Eutrophication index is calculated as:

$$E = \frac{C_{COD} \times C_{DIN} \times C_{DIP} \times 10^6}{4500} \quad \dots\dots\dots (4)$$

where

E —eutrophication index;

C_{COD} —organic matter in water with the unit of milligrams per liter (mg/L);

C_{DIN} —inorganic nitrogen in water, i.e., the sum of ammonia nitrogen, nitrite and nitrate, with the unit of milligrams per liter (mg/L);

C_{DIP} —active phosphate in water with the unit of milligrams per liter (mg/L).

Table 8 – Evaluation index and valuation of eutrophication in bay

Index	I	II	III
E	≤ 1	$> 1 \sim \leq 9$	> 9
Value	40	25	10
Note: The index is averaged on individual index at each station.			

e) Primary productivity

Primary productivity index is calculated as:

$$P_t = \left| \frac{P - P_0}{P_0} \right| \times 100\% \quad \dots\dots\dots (5)$$

where

P_t —primary productivity index;

P —daily primary productivity on site in the evaluation year taking the average at each station, with the unit of milligram carbon per square meter per day ($mgC/m^2 \cdot d$);

P_0 —daily primary productivity on site in the reference system with the unit of milligram carbon per square meter per day ($mgC/m^2 \cdot d$).

Table 9 – Evaluation index and valuation of primary productivity in bay

Index	I	II	III
Primary productivity variation	$\leq 20\%$	$> 20\% \sim \leq 40\%$	$> 40\%$
Value	40	25	10

Primary productivity is estimated using chlorophyll a method:

$$P = \frac{P_s \cdot E \cdot D}{2} \quad \dots\dots\dots (6)$$

where

P_s —Potential productivity of phytoplankton in surface water, with the unit of milligram carbon per cubic meter per hour ($\text{mgC}/\text{m}^3 \cdot \text{h}$);

E —Depth of euphotic layer, with the unit of meter (m), taking shallower depth between the three times of transparency and the local water depth;

D —Illumination duration, with the unit of hours per day (h/d), taking spring illumination duration as 12 h/d, and summer illumination duration as 14 h/d.

Potential productivity of phytoplankton in surface waters (P_s) is calculated as:

$$P_s = C_a Q \quad \dots\dots\dots (7)$$

where

C_a —the chlorophyll a in surface water, with the unit of milligram per cubic meter (mg/m^3);

Q —assimilation coefficient = $3.7 \text{ mgC}/\text{mgChl-a} \cdot \text{h}$.

f) Mangrove, salt marsh, coral reefs, seagrass bed, oyster reefs, sandy coast, and estuarine ecosystems

Based on the assessment results of each ecosystem, evaluation index of primary productivity is assigned 40 for stable ecosystem; 25 for damaged ecosystem; and 10 for severe damaged ecosystem. For multiple ecosystems, it takes the average as the habitat index.

g) Habitat index is calculated as:

$$CEH_h = \frac{\sum_1^i H_i}{i} \quad \dots\dots\dots (8)$$

where

CEH_h —habitat index;

H_i —values of each habitat indicator;

i —total number of habitat indicators.

6.2.2.3 Biology

a) The number of fish eggs and larvae and swimming animals are calculated as:

$$N_t = \left| \frac{N - N_0}{N_0} \right| \times 100\% \quad \dots\dots\dots (9)$$

where

N_t —index of fish eggs and larvae and swimming animals;

N —number of fish eggs and larvae (ind/m^3) and swimming animals (ind/h) in bay in the evaluation year;

N_0 —the average of the evaluation index in the reference system.

Table 10 – Evaluation index and valuation of fish eggs and larvae and swimming animals in bay

Index	I	II	III
Reduction of fish eggs	$\leq 20\%$	$>20\% \sim \leq 50\%$	$>50\%$
Reduction of fish larvae	$\leq 20\%$	$>20\% \sim \leq 50\%$	$>50\%$
Reduction of swimming animals	$\leq 20\%$	$>20\% \sim \leq 50\%$	$>50\%$
Value	40	25	10
Note 1: The value of fish eggs and larvae and swimming animals is assigned 40 if increased from the base year.			
Note 2: The index is averaged on individual index for fish eggs, larvae and swimming animals.			

b) The Shannon-Wiener index is calculated as:

$$H' = -\sum_{i=1}^S P_i \ln P_i \quad \dots\dots\dots (10)$$

where

H' —the Shannon-Wiener index;

S —total number of species;

P_i —the ratio of the individuals of type i to the total investigated number;

N —the total number of organisms in the sample.

Table 11 – Biodiversity index and valuation in bay

Index	I	II	III
H'	>3	$>1 \sim \leq 3$	≤ 1
Value	40	25	10
Note: The species diversity index is averaged on individual index of phytoplankton, zooplankton and large benthic organisms.			

c) Species quantity is calculated as:

$$W_t = \left| \frac{W - W_0}{W_0} \right| \times 100\% \quad \dots\dots\dots (11)$$

where

W_t —biological species index;

W —biological species quantity in the evaluation year;

W_0 —biological species quantity in the reference system.

Table 12 – Species quantity index and valuation in bay

Index	I	II	III
Biological species reduction	$\leq 5\%$	$>5\% \sim \leq 10\%$	$>10\%$
Value	40	25	10
Note1: The value of biological species is assigned 40 if increasing from the base year. Note2: The number of species is the sum of phytoplankton, zooplankton, macrobenthos, intertidal organisms, swimming animals and tidal-flat wetland wildlife.			

d) Biology index in bay is calculated as:

$$CEH_s = \frac{\sum_{i=1}^i S_i}{i} \quad \dots\dots\dots (12)$$

where

CEH_s —biology index;

S_i —individual biology index;

i —number of biology index.

6.2.2.4 Ecosystem pressure

a) Reclamation area is calculated as:

$$At = \frac{Ar}{Ar_0} \quad \dots\dots\dots (13)$$

where

A_t —reclamation area evaluation index;

A_r —total reclaimed area at the evaluation time, with the unit of square kilometer (km^2);

A_{r0} —reclamation area in the reference system, with the unit of square kilometer (km^2).

b) Artificial shoreline length is calculated as:

$$L_t = \frac{L}{L_0} \quad \dots\dots\dots (14)$$

where

L_t —artificial shoreline index;

L —artificial shoreline length in the evaluation year, with the unit of kilometer (km);

L_0 —artificial shoreline length in the reference system, with the unit of kilometer (km).

c) Aquaculture area is calculated as:

$$Y_t = \frac{Y}{Y_0} \dots\dots\dots (15)$$

where

Y_t —aquaculture area index;

Y —aquaculture area in the evaluation year, with the unit of square kilometer per year (km²/a);

Y_0 —aquaculture area in the base year, with the unit of square kilometer per year (km²/a);

d) Accumulated red-tide area is calculated as:

$$R_t = \frac{R}{R_0} \dots\dots\dots (16)$$

where

R_t —accumulated red-tide area index;

R —accumulated red-tide area in the evaluation year, with the unit of square kilometer per year (km²/a);

R_0 —accumulated red-tide area in the base year, with the unit of square kilometer per year (km²/a).

Table 13 – Evaluation index and valuation of ecosystem pressure in bay

Index	I	II
A_t	≤ 1	> 1
L_t	≤ 1	> 1
Y_t	≤ 1	> 1
R_t	≤ 1	> 1
Value	20	10
Note 1: When the base year is 0 and the evaluation year is not 0, the index is 10. When both the base year and evaluation year are 0, this index is not accounted in.		
Note 2: The ecosystem pressure index is averaged on individual index of reclamation area, artificial shoreline length, aquaculture area and accumulated red-tide area.		

d) Ecosystem pressure index is calculated as:

$$CEH_p = \frac{\sum_1^i P_i}{i} \dots\dots\dots (17)$$

where

CEH_p —ecosystem pressure index;

P_i —evaluation results of ecosystem stress index;

i —number of ecosystem pressure index.

6.3 Comprehensive evaluation

Comprehensive evaluation is calculated as:

$$CEH_{index} = CEH_r + CEH_s + CEH_p \dots\dots\dots (18)$$

$CEH_{index} > 80$ indicates a stable bay ecosystem; $60 \leq CEH_{index} \leq 80$ indicates a damaged bay ecosystem;

$CEH_{index} < 60$ indicates a severe damaged bay ecosystem.

Annex A
(annex normative)
Bay ecosystem questionnaire

Table A.1 Bay ecosystem survey

Page No.

Organization: yyyy/mm/dd		Filling time:		
Survey elements	Ecological system:			
	Survey time:			
	Survey location:			
	Survey range (Latitude and longitude range):			
Survey method		Field measurement Remote sensing image analysis Others		
Field measurement information (required for field investigation, optional for other methods)				
Measurement site	Longitude	Latitude	Photo (video) number	Note
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Surveyor		Recorder		Reviewer
Data source				
Note				

Completed by:

Checked by:

Annex B
(annex normative)
Coastline status questionnaire

Table B.1 Coastline status questionnaire

Survey time: yyyy/mm/dd

Organization			Geographical location	Province City County (District)	
Coastline distribution	Coastline range		Origin coordinates:		
			Terminal coordinates:		
	Coastline type and length (km)				
Damage to shoreline and beach		Length of damaged coastline (km)			
		Reason for damage		Natural evolution Human activities	
		Damage degree			
Development and utilization		Reclamation, port shipping and so on			
Has the coastline been repaired		Yes No			
Survey method		Field measurement Remote sensing image analysis Others			
Field measurement information (required for field investigation, optional for other methods)					
Measurement site	Longitude	Latitude		Photo (video) number	Note
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
Surveyor		Recorder		Reviewer	
Data source					
Note					
Note: Damage degree column describes erosion rate, erosion width, erosion ridge height, sandy coastline argillization, coarsening and occupation, etc.					

Annex C
(annex normative)
Reclamation status questionnaire

Table C.1 Reclamation status questionnaire

Survey time: yyyy/mm/dd

Organization			Geographical location	Province City County (District)	
Distribution of reclamation	Reclamation range		Origin coordinates:		
			Terminal coordinates:		
	Length of coastline formed by reclamation (km)				
Artificial coastline		Length of bank revetment (km)			
		Length of seawall (km)			
		Reason for damage		Natural evolution Human activities	
		Damage degree			
Development and utilization of surrounding areas (within 5 km)		Aquaculture, port shipping, engineering construction, etc.			
Has the coastline been repaired		Yes No			
Survey method		Field measurement Remote sensing image analysis Others			
Field measurement information (required for field investigation, optional for other methods)					
Measurement site	Longitude	Latitude		Photo (video) number	Note
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
Surveyor		Recorder		Reviewer	
Data source					
Note					