



Social Organization Standard

T/CAOE 20.9-2020

Technical guideline for investigation and assessment of coastal ecosystem —

Part 9:

Estuary

海岸带生态系统现状调查与评估技术导则 第9部分：河口

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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 9 of the 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*.

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Technical guideline for investigation and assessment of coastal ecosystem —

Part 9: Estuary

1 Scope

This part of the Standard (T/CAOE 20) specifies the investigation contents and methods, as well as the assessment indicators and methods of coastal ecosystem.

This part is applicable to the investigation and assessment of estuarine ecosystem for protection and remediation activities of coastal zone. It may also be used as reference for other related issues.

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 3097-1997, *Sea water quality standard*

GB/T 12763.2, *Specifications for oceanographic survey—Part 2: Marine hydrographic observation*

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 17378.3, *The specification for marine monitoring—Part 3: Sample collection, storage and transportation*

GB 17378.4, *The specification for marine monitoring—Part 4: Seawater analysis*

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 18668, *Marine sediment quality*

HY/T080-2005, *Technical specification for coastal wetland eco-monitoring*

HY/T085-2005, *Technical specification for eco-monitoring of estuaries*

HY/T147.1-2013, *Code for practice for marine monitoring technology—Part 1: Seawater*

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

T/CAOE 20.2-2020, *Technical guideline for investigation and assessment of coastal ecosystem—Part 2: Remote sensing identification and results verification of the coastal ecosystem*

T/CAOE 20.4-2020, *Technical guideline for investigation and assessment of coastal ecosystem—Part 4: Salt marshes*

3 Terms and definitions

For the purposes of this part, the following terms and definition apply.

3.1

estuary

an area where the river terminal is combined with the ocean, including near-estuarine area, estuarine area and offshore area

NOTE The near-estuarine area is an area between the locations of the tidal limit and the tidal current limit. The estuarine area is an area between the locations of the tidal current limit and the estuary mouth. The offshore area is an area between the locations of the estuary mouth and the subaqueous delta front.

3.2

delta estuary

an estuary with abundant incoming sand in the basin, where sediment is deposited in the estuary area, and delta is developed

3.3

drowning estuary

an estuary with smaller rivers or less sand coming from the basin, where although there is sediment accumulation in the bay head or some areas, the drowning state still remains, with the lower part often being funnel-shaped

3.4

estuarine ecosystem

a unified whole composed of the marine environment and the biological community where fresh water and sea water mix and influence each other in the river estuary

[Rewriting, HY/T085-2005, Definition 3.1]

3.5

estuarine habitats

the seawater and marine sediment environment where organisms in the estuary area depend for survival

4 General provisions

4.1 Work procedure

According to the requirements given in T/CAOE 20.1-2020, Clause 5.

4.2 Quality control

According to the requirements given in T/CAOE 20.1-2020, 4.3.

4.3 Design of investigation scheme

According to the requirements given in T/CAOE 20.1-2020, Clause 6.

4.4 Result of work

According to the requirements given in T/CAOE 20.1-2020, Clause 9.

4.5 Filing of data and result

According to the requirements given in T/CAOE 20.1-2020, Clause 10.

5 Scope of investigation and assessment

5.1 General requirement of investigation and assessment

The scope of the investigation and assessment of the estuarine ecosystem shall be considered according to the specific characteristics of each estuary, which shall in principle cover the entire estuarine ecosystem zones, including near-estuarine area, estuarine area, offshore area etc.

5.2 Scope of investigation and assessment in a delta estuary

The estuarine topography, geomorphology, hydrology, biology and other elements shall be considered. According to the field investigation and historical data analysis, combined with numerical simulation, topographic and geomorphic characteristics, and the distribution of species living in saltwater and freshwater, the tidal limit and the open water boundary that is impacted by the river and sediment entering the sea should be determined. Afterwards, the investigation and assessment scope of estuarine ecosystem should be comprehensively analyzed.

5.3 Scope of investigation and assessment in a drowning estuary

The topography, geomorphology and hydrology of the estuary shall be considered. According to the field investigation and historical data analysis, combined with the numerical simulation, and topographic and geomorphic characteristics, the investigation and assessment scope of estuarine ecosystem should be comprehensively analyzed.

6 Status investigation

6.1 Investigation content

The investigation of estuarine ecosystem includes coastal wetland, estuarine habitats, bio-ecosystem, estuarine hydrological connectivity and ecological pressure factors. According to the characteristics of different estuarine ecosystems, all or part of the indicators in Table 1 should be selected.

Table 1 — Investigation content and methods of estuarine ecosystem

Investigation content	Investigation indicators and elements	Investigation methods
Coastal wetland ^a	Wetland type, wetland areas, etc.	Remote sensing interpretation, field verification
	Vegetation type and vegetation area, with a focus on alien organisms like <i>spartina alterniflora</i> ^b	Remote sensing interpretation, field verification
	Status of wading structures	Data collecting, assisted by remote sensing interpretation or field verification when necessary
Estuarine habitats	Inorganic nitrogen, active phosphate, Chemical oxygen demand, dissolved oxygen, active silicate, suspended substance and heavy metal (Hg, Cu, Pb, Cd, Zn, Cr, etc.) in sea water	Shipboard survey at measuring sites
	Marine sediment: grain size, organic carbon, sulfide, etc.	Shipboard survey at measuring sites
	Oceanographic data: water depth, salinity, transparency, flow velocity and flow direction, etc.	Shipboard survey at measuring sites; measurement of the optional investigation indicators such as flow velocity, flow direction; or data collecting
	Topography situation: coastal erosion and deposition, including the variation of water depth, hydrodynamic conditions, sediment transport and etc.	Remote sensing interpretation; investigation by ship motion; or data collecting
Estuarine bio-ecosystem	Chlorophyll-a, phytoplankton, zooplankton, macrobenthos	Shipboard survey at measuring sites
	Species and their density in the intertidal zone	Field survey
	Fish eggs, larvae, netkon	Shipboard survey at measuring sites and data collecting
	Rare and endangered species, key protected wildlife, etc. ^c	Fixed site observation and data collecting
Ecological pressure factors	Runoff into the sea: monthly freshwater inflows, sediment concentration, etc.	Data collecting

	Hydrological connectivity in estuary: construction of sluices and dams in estuary; design and layout of fish passage facilities; influence of dredging engineering in waterway	Data collecting, and using remote sensing interpretation, assisted by field verification when necessary
	Sewage effluents: total amount of river pollutants; concentration of river pollutants; situation of pollutants entering the sea at sewage outlets	Data collecting
	Human activities: coastal reclamation (area, distribution, plane layout, etc.); dykes and dams (distribution, length, etc.); oil field(quantity, construction method, etc.); breeding (type, method, area); marine fishing (fishing methods, species of fish caught, catch amount), etc.	Data collecting, and using remote sensing interpretation, assisted by field verification when necessary
^a Coastal wetland refers to the water area with water depth less than 6 m at low tide and its coastal wet zone. ^b Alien organisms are defined according to literature or other published research results. ^c Rare and endangered species, key protected wild animals and plants only refer to the species listed in <i>Convention on International Trade in Endangered Species of Wild Fauna and Flora</i> , <i>China Red Data Book on Endangered Animals</i> , <i>List of Endangered Rare Animals in China</i> , <i>List of National Key Protected Wild Animals (in China)</i> .		

6.2 Investigation and analysis method

6.2.1 Layout of stations

The layout of stations is as follows:

—The layout of estuarine habitat and bio-ecological survey stations shall follow the principle of full-coverage and key-representative. Generally, the survey stations are arranged along the diffusion zone of the freshwater emptying into the sea at certain intervals, showing a frontal shape, covering the estuarine sea area. In the large estuaries with an area of more than 1000 square kilometers, like the Yangtze River, the Yellow River, the Pearl River, and Liaohe River, the number of stations should be 20 to 40. In the other estuaries with a basin area less than 1000 square kilometers, the number of stations should be 10 to 20. The stations should be appropriately densified at the confluence of rivers and oceans. The number of ecological and sediment stations generally shall be more than 60% of the total survey stations of seawater chemical elements.

—For the estuarine ecosystem with coastal wetland vegetation, in addition to the investigation of the estuarine habitat and estuarine bio-ecosystem, the estuarine coastal wetland vegetation survey shall be carried out in principle. The station layout should be carried out according to the requirements given in T/CAOE 20.4-2020, Clause 6.

6.2.2 Investigation and analysis method

The method in Table 2 is applied to the investigation of estuarine ecosystem factors.

Table 2 — Investigation and analysis method of estuarine ecosystem factors

Investigation indicators	Investigation factor	Investigation and analysis method
Wetland	Wetland type, wetland areas	T/CAOE 20.2-2020
	Vegetation type	HY/T080-2005
	Vegetation area	T/CAOE 20.2-2020
	Construction conditions of wading structures	Data collecting, assisted by remote sensing interpretation or field verification when necessary
Sea water	Inorganic nitrogen	GB 17378.3, GB 17378.4, HY/T 147.1-2013

Investigation indicators	Investigation factor	Investigation and analysis method
	Active phosphate	GB 17378.3, HY/T147.1-2013
	Chemical oxygen demand	GB 17378.3, GB 17378.4
	Dissolved oxygen	GB 17378.3, GB 17378.4
	Active silicate	GB 17378.3, GB 17378.4
	Heavy metal (Hg, Cu, Pb, Cd, Zn, Cr, etc.)	GB 17378.3, GB 17378.4
	Suspended matter	GB 17378.3, GB 17378.4
Marine sediment	Grain size	GB 17378.3, GB/T 12763.8
	Organic carbon	GB 17378.3, GB 17378.5
	Sulphide	GB 17378.3, GB 17378.5
Marine hydrology	Water depth	GB/T 12763.2
	Salinity	GB/T 12763.2
	Transparency	GB/T 12763.2
	Flow velocity and direction	GB/T 12763.2
Topography and geomorphology	Coastal erosion and deposition	According to the actual condition of different estuaries, the remote sensing images within 3 years, 5 years or 10 years may be selected for comparison. In areas with little change in topography and geomorphology, it may be analyzed by collecting the recent historical data. RTK measurement method assorted with UAV telemetry technology can be used when necessary.
Marine organisms	Chlorophyll-a	GB/T 12763.6, GB 17378.7
	Phytoplankton	GB 17378.3, GB 17378.7
	Zooplankton	GB 17378.3, GB 17378.7
	Macrobenthos	GB 17378.7
	Intertidal organism	GB 17378.7
	Fish eggs and larvae	GB/T 12763.6
	Netkon	GB/T 12763.6
	Rare and endangered species	Data collecting, assisted by fixed site observation when necessary
	National protected animals	
Estuarine hydrological connectivity	Construction location and influence range of river dam, etc.	Data collecting, and using remote sensing interpretation, assisted by field verification when necessary
	Dredging range, construction method and influence range of channel engineering, etc.	Data collecting, assisted by field verification when necessary

6.3 Survey frequency

The frequency of investigation depends on the actual condition of each estuary. In general, the survey of estuarine habitat and bio-ecosystem shall be carried out once in the flood season. The investigation should be carried out or not according to circumstances while in the dry season and

normal water season. And the main task is to collect data. A survey of coastal wetland vegetation, intertidal organisms, and alien organisms, *spartina alterniflora*, should be conducted between May and August.

7 Assessment of ecosystem

7.1 Selection principle of the standard value of the assessing year

The selection principle of the standard value of the assessing year are as follows:

—Collect the historical data of the survey area, including the ecosystem data obtained from routine monitoring, special investigation, academic research, etc. as a reference frame, and compare and analyze the current situation of the ecosystem.

—In principle, the standard value (background value) of the assessing year shall select the average value of monitoring data within three or five years in the sea area or comparable adjacent areas. The background data of the same season shall be selected for the marine ecological background value. And the data of the same water period (dry season, flood season, normal water season) are selected for the background value of water quality and hydrology. The appropriate literature value may be selected in case of insufficient historical data.

7.2 Assessment of coastal wetland

7.2.1 Coastal wetland area

The area of coastal wetland is interpreted by remote sensing, and its spatial scope of assessment should be determined according to the actual condition of different estuaries. In principle, it should cover the entire estuarine ecosystem zones. Normally it may select the area from supratidal zone to the sea area where water depth reaches - 6m. On the time scale of years, remote sensing images within 3 years, 5 years or 10 years should be selected for comparison. The assessment of coastal wetland area is calculated by Equation (1).

$$W_t = \frac{W}{W_0} \times 100\% \quad \dots\dots\dots (1)$$

where

W_t — percentage of coastal wetland area;

W — coastal wetland area of the assessing year (km^2);

W_0 — coastal wetland area of the base year (km^2).

If $W_t \geq 100\%$, it means that the coastal wetland area is not damaged, the larger W_t is, the better the wetland area is; if $W_t < 100\%$, it means that the wetland area is damaged, and the damage degree should be assessed according to Table 3.

Table 3 — Assessment of damage degree of coastal wetland area

5-year reduction rate of coastal wetland area	$\leq 5\%$	$>5\% \sim 10\%$	$>10\%$
Degrees of degradation	Slight	Moderate	Severe

5-year reduction rate of coastal wetland area is calculated by Equation (2).

$$\Delta W_t = \frac{W_0 - W}{W_0 \times \Delta y} \times 5 \times 100\% \quad \dots\dots\dots (2)$$

where

ΔW_t — 5-year reduction rate of coastal wetland area %;

W — coastal wetland area of the assessing year (km^2);

W_0 — coastal wetland area of the base year (km^2);

Δy — time interval between the assessing year and the base year (a).

7.2.2 Vegetation area of coastal wetland

Vegetation area of coastal wetland is interpreted with remote sensing information. The vegetation

area of coastal wetland is assessed by Equation (3).

$$V_e = \frac{V}{V_0} \times 100\% \quad \dots\dots\dots (3)$$

where

V_e — percentage of vegetation area of coastal wetland;

V — coastal wetland vegetation area of the assessing year (km^2);

V_0 — coastal wetland vegetation area of the base year (km^2).

If $V_e \geq 100\%$, it means that the coastal wetland vegetation is not damaged, the larger V_e is, the better the wetland vegetation condition is; if $V_e < 100\%$, it means that the wetland vegetation is damaged, and the damage degree should be assessed according to Table 4.

Table 4 — Assessment of damage degree of vegetation area of coastal wetland

5-year reduction rate of vegetation area of coastal wetland	$\leq 5\%$	$>5\% \sim \leq 10\%$	$>10\%$
Degrees of degradation	Slight	Moderate	Severe

5-year reduction rate of vegetation area of coastal wetland is calculated by Equation (4).

$$\Delta V_e = \frac{V_0 - V}{V_0 \times \Delta y} \times 5 \times 100\% \quad \dots\dots\dots (4)$$

where

ΔV_e — 5-year reduction rate of coastal wetland vegetation area %;

V — coastal wetland vegetation area of the assessing year (km^2);

V_0 — coastal wetland vegetation area of the base year (km^2);

Δy — time interval between the assessing year and the base year (a).

7.2.3 The area of biological invasion

The area of biological invasion is analyzed by remote sensing or field survey. The area of biological invasion is assessed by Equation (5).

$$I_v = \frac{I}{I_0} \times 100\% \quad \dots\dots\dots (5)$$

where

I_v — percentage increase of the biological invasion area;

I — biological invasion area of the same species of the assessing year (km^2);

I_0 — biological invasion area of the same species of the base year (km^2).

If $I_v \geq 100\%$, it means that the coastal wetland is invaded by alien organisms, and the damage degree should be assessed according to Table 5; if $I_v < 100\%$, it means that the coastal wetland is not damaged, the smaller I_v is, the better the coastal wetland is.

Table 5 — Assessment of damage degree of the alien organisms in coastal wetland

5-year increase rate of the biological invasion area	$\leq 5\%$	$>5\% \sim \leq 10\%$	$>10\%$
Degrees	Slight	Moderate	Severe

5-year increase rate of the biological invasion area is calculated by Equation (6).

$$\Delta I_v = \frac{I - I_0}{I_0 \times \Delta y} \times 5 \times 100\% \quad \dots\dots\dots (6)$$

where

ΔI_v — 5-year increase rate of the biological invasion area %;

I — biological invasion area of the same species of the assessing year (km^2);

I_0 — biological invasion area of the same species of the base year (km^2);

Δy — time interval between the assessing year and the base year (a).

7.2.4 Assessment of coastal wetland damage

According to the actual condition of estuarine ecosystem, all or one of the indicators, such as the area of coastal wetland, vegetation area and invasion of alien organisms, may be selected for assessment. If any of the indicators is in a damaged state, the assessment result of estuarine coastal wetland is determined as “damaged”. The comprehensive damage level is determined by the indicator with the highest damage level among multiple assessment indicators.

7.3 Assessment of estuarine habitat

7.3.1 Seawater quality

7.3.1.1 Water Eutrophication

Water eutrophication is calculated by Equation (7).

$$E = \frac{COD \times DIN \times DIP}{4500} \times 10^6 \quad \dots\dots\dots (7)$$

where

E — index of water eutrophication;

COD — chemical oxygen demand (mg/L);

DIN — concentration of dissolved inorganic nitrogen (mg/L);

DIP — concentration of dissolved inorganic phosphorus (mg/L).

If $E > 1$, it indicates that the sea water is in eutrophic state; conversely, the sea water is not in eutrophic state.

The evaluation of water eutrophication is analyzed by Equation (8).

$$E_t = \frac{N}{N_0} \times 100\% \quad \dots\dots\dots (8)$$

where

E_t — percentage of eutrophication index change;

N — mean eutrophication index of each monitoring station of the assessing year;

N_0 — mean eutrophication index of each monitoring station of the base year.

If $E_t \geq 100\%$ and $E > 1$, it means that the eutrophication degree of water is high, and the damage degree should be assessed according to Table 6; if $E_t < 100\%$ or $E \leq 1$, it indicates the low eutrophication degree, the smaller E_t or E is, the better the seawater quality is.

Table 6 — Assessment of damage degree of water eutrophication indicators in estuarine habitat

Index of water eutrophication E	$1 > \sim \leq 3$	$> 3 \sim \leq 9$	> 9
Degrees	Slight	Moderate	Severe

7.3.1.2 Salinity percentage

The average salinity of each monitoring station during the same period is used for assessment which is calculated by Equation (9).

$$S_A = \frac{S}{S_0} \times 100\% \quad \dots\dots\dots (9)$$

where

S_A — percentage of average salinity;

S — average salinity of each monitoring station of the assessing year;

S_0 — average salinity of each monitoring station of the base year.

If $S_A > 100\%$ and $S > 28$, it means that the salinity of the estuary is higher, and the damage degree is assessed according to Table 7; if $S_A \leq 100\%$, it means that the salinity of the sea area is reduced, the smaller S_A is, the better the salinity condition of estuarine habitat is.

Table 7 — Assessment of damage degree of salinity indicators of sea area in estuarine habitat

Variation amplitude of annual average salinity	$\leq 3\%$	$>3\% \sim \leq 5\%$	$>5\%$
Degrees	Slight	Moderate	Severe

The variation amplitude of salinity is calculated by Equation (10).

$$\Delta S_A = \frac{S - S_0}{S_0} \times 100\% \quad \dots\dots\dots (10)$$

where

ΔS_A — variation amplitude of annual average salinity;

S — average salinity of each monitoring station of the assessing year;

S_0 — average salinity of each monitoring station of the base year.

7.3.1.3 Heavy metal indicators in seawater

According to the characteristics of each estuary, heavy metal in seawater, such as Cu, Pb, Zn, Cd, Cr, Hg, can be selected as monitoring indicators and calculated by Equation (11).

$$M_h = \frac{M}{M_0} \times 100\% \quad \dots\dots\dots (11)$$

where

M_h — percentage of heavy metal indicators;

M — concentration of heavy metals indicators in seawater of the assessing year (mg/L);

M_0 — concentration of heavy metals indicators in seawater of the base year (mg/L).

If $M_h \geq 100\%$ and the concentration of monitoring indicators in seawater exceeds the second grade of GB 3097-1997, it means that the seawater quality is damaged, and the damage degree is assessed according to Table 8; if $M_h < 100\%$ or the concentration of monitoring indicators in seawater does not exceed the second grade of GB 3097-1997, it means that the seawater quality is getting better, the smaller M_h is, the better the seawater condition in the estuary is.

Table 8 — Assessment of damage degree of heavy metal indicators of seawater in estuarine habitat

Concentration of monitoring indicators in seawater	The standard of Grade 2-3 of GB 3097-1997	The standard of Grade 3-4 of GB 3097-1997	Exceeding the standard of Grade 4 of GB 3097-1997
Degrees	Slight	Moderate	Severe

7.3.2 Indicators of marine sediment quality

According to the characteristics of each estuary, sulfide or other representative of marine sediment can be selected as monitoring indicators and calculated by Equation (12).

$$Z_L = \frac{Z}{Z_0} \times 100\% \quad \dots\dots\dots (12)$$

where

Z_L — percentage of the monitoring indicators of marine sediment;

Z — contents of the marine sediment indicators of the assessing year;

Z_0 — contents of the marine sediment indicators of the base year.

If $Z_L \geq 100\%$ and the content of monitoring indicators in sediments exceeds the standard of GB 18668, it means that the quality of marine sediments is damaged, and the degree of damage should be assessed according to Table 9; if $Z_L < 100\%$ or the content of monitoring indicators in marine sediments does not exceed the standard of GB 18668, it indicates that the quality of marine sediments is getting better, the smaller Z_L is, the better the quality of marine sediments is.

Table 9 — Assessment of damage degree of marine sediment quality in estuarine habitat

Concentration of	Grade 1-2 of GB 18668	Grade 2-3 of GB 18668	Exceeding Grade 3 of GB
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monitoring indicators in sediments			18668
Degrees	Slight	Moderate	Severe

7.3.3 Assessment of estuarine habitat damage

According to the actual condition of the estuarine ecosystem, all or part of the indicators, such as seawater quality and marine sediment quality, are selected to assess the estuarine habitat damage. If any of the indicators is in a damaged state, the assessment result of estuarine habitat is determined as “damaged”. The comprehensive damage level is determined by the indicator with the highest damage level among multiple assessment indicators.

7.4 Estuarine bioecological assessment

7.4.1 Primary productivity

The primary productivity is estimated by Equation (13).

$$P = \frac{P_s \times E \times D}{2} \quad \dots\dots\dots (13)$$

where

P — daily primary productivity, in organic carbon per square meter per day ($\text{mg}/(\text{m}^2 \cdot \text{d})$);

P_s — potential productivity of phytoplankton in surface water, in organic carbon per hour per cubic meter ($\text{mg}/(\text{m}^3 \cdot \text{h})$);

E — depth of euphotic layer, which is three times of transparency. When the water depth is less than three times of the transparency, the depth of euphotic layer is assumed to equal to the water depth.

D — illumination time, in hours per day. It is assumed to be 12 h/d in spring and 14 h/d in summer.

P_s is calculated by Equation (14) according to the content of chlorophyll-a in surface water

$$P_s = C_a \times Q \quad \dots\dots\dots (14)$$

where

C_a — content of chlorophyll-a in surface water (mg/m^3);

Q — assimilation coefficient, in organic carbon per milligram of chlorophyll-a per hour, with the value of 3.7.

Loss of primary productivity is assessed by Equation (15)

$$P_d = \frac{P}{P_0} \times 100\% \quad \dots\dots\dots (15)$$

where

P_d — percentage of primary productivity change;

P — estimated average value of primary productivity of the assessing year;

P_0 — estimated average value of primary productivity of the base year.

If $P_d \geq 90\%$, it means that the primary productivity is not damaged, the higher the percentage is, the better the primary productivity is; if $P_d < 90\%$, it indicates that the primary productivity is damaged, the lower the percentage is, the more severe the damage is. The degree of damage is assessed according to Table 10.

Table 10 — Assessment of damage degree of primary productivity of sea area

Variation amplitude of primary productivity	$\leq 20\%$	$>20\% \sim \leq 40\%$	$>40\%$
Degrees	Slight	Moderate	Severe

The variation amplitude of primary productivity is calculated by Equation (16).

$$\Delta P_d = \frac{P - P_0}{P_0} \times 100\% \quad \dots\dots\dots (16)$$

where

P_d — variation amplitude of primary productivity;

P — estimated average value of primary productivity of the assessing year;

P_0 — estimated average value of primary productivity of the base year.

7.4.2 Macrobenthic diversity index

Shannon-Wiener diversity index (H') is used, expressed as Equation (17)

$$H' = -\sum_{i=1}^S (n_i / N) \log_2 (n_i / N) \quad \dots\dots\dots (17)$$

where

H' — bio-diversity index of the assessing year;

S — species;

n_i — number of individuals of type i , in individual per square meter (ind/m²);

N — total individual number, in individual per square meter (ind /m²).

The bio-diversity index is assessed by Equation (18)

$$H_d = \frac{H'}{H'_0} \times 100\% \quad \dots\dots\dots (18)$$

where

H_d —percentage of bio-diversity index change;

H' —average value of bio-diversity index of the assessing year;

H'_0 —average value of bio-diversity index of the base year.

If $H_d \geq 90\%$, it means that the macrobenthos diversity is not damaged, the higher H_d is, the better the macrobenthic biodiversity is; if $H_d < 90\%$, it means that the macrobenthic biodiversity is damaged, and the damage degree is assessed according to Table 11.

Table 11—Assessment of damage degree of Macrobenthos of sea area

H'	>2	$>1 \sim \leq 2$	≤ 1
Degrees	Slight	Moderate	Severe

7.4.3 Assessment of important organisms

The occurrence frequency or quantity of fish eggs, larvae/juveniles, rare and endangered species, and national protected animals in the assessment area are taken as the assessment indicators. And the expert experience method is used to analyze and assess the conditions of important organisms in the estuarine ecosystem.

7.4.4 Assessment of estuarine ecological damage

According to the actual condition of the estuarine ecosystem, all or part of the indicators, such as primary productivity, macrobenthic diversity index, fish eggs, larvae/juveniles and etc., are selected to assess the estuarine bio-ecological damage. If any one of the indicators is in a damaged state, the result of the estuarine bioecological assessment is determined as “damaged”. The comprehensive damage level is determined by the indicator with the highest damage level among multiple assessment indicators.

7.5 Assessment of hydrological connectivity in estuary

According to the actual condition of the estuarine ecosystem, one should assess the hydrological connectivity of the estuary and evaluate the impact of the construction projects, such as dykes and dams, on the inflow runoff as well as the obstruction of fish spawning channel upstream. The damage status is assessed by expert evaluation method.

7.6 Comprehensive assessment

According to the actual condition of the estuarine ecosystem, all or part of the assessment indicators, such as estuarine coastal wetland, estuarine habitat, estuarine bio-ecosystem and estuarine hydrological connectivity, are selected for comprehensive assessment of estuarine ecosystem damage. If any of the assessment indicators is in a damaged state, the assessment result of estuarine ecosystem is “damaged”. The comprehensive damage level is determined by the indicator with the highest damage level among multiple assessment indicators.

7.7 Cause analysis of damage

According to the comprehensive assessment results of estuarine ecosystem damage, combined with the ecological pressure factors, the causes of the damage should be analyzed. For the damaged areas caused by human activities, the suggestions on the selection of key or priority areas of restoration should be put forward, and the direction of restoration should be suggested.

8 Preparation of assessment reports

8.1 Principles of reports preparation

The assessment report shall comprehensively summarize the assessment content. The text is required to be concise and accurate. Use as many charts and photos as possible for easy reading and review. The original data and calculation process may be included in the Annex.

8.2 Main contents of reports

The main contents of the assessment report shall include: task source of investigation and assessment, purpose and significance, scope of investigation and assessment, technical methods of investigation and assessment, present situation of ecosystem, assessment results of ecosystem damage, cause analysis, countermeasures and suggestions, etc. See Annex A for the main clauses of the report.

8.3 Requirements for map and data in the report

Report maps should be handled according to the requirements given in T/CAOE 20.1-2020, 9.2. The reports data set should be handled according to the requirements given in T/CAOE 20.1-2020, 9.3. The survey data of ecological pressure factors should be conducted according to the requirements of Annex B.

Annex A

(annex informative)

Investigation and assessment reports of estuarine ecosystem

A.1 Summary

A.1.1 General requirements

The task source and purpose of the assessment shall be clarified. The regional characteristics and the main ecological problems of the estuary ecosystem should be introduced. The text is required to be concise and accurate.

A.1.2 Task source and purpose

A.1.3 Regional characteristics

A.1.4 Main ecological problems

A.2 Overview of natural and social environment

A.2.1 General requirements

The regional natural environment, social economy, major marine ecological problems and ecological pressure shall be discussed in detail.

A.2.2 Regional natural environment situation

A.2.3 Regional social economy situation

A.2.4 Regional ecological problems and ecological pressure situation

A.3 Investigation on the status of estuary ecosystem

A.3.1 General requirements

The contents, methods and implementation process of field investigation shall be discussed in detail, with necessary images or videos. Moreover, the field sample collection, sample analysis and data processing should be described in detail with necessary charts.

A.3.2 Investigation on the status of coastal wetland

A.3.2.1 Scope, contents and methods of investigation

A.3.2.2 Implementation process of investigation

A.3.2.3 Results of investigation

A.3.3 Investigation on the status of marine habitats

A.3.3.1 Scope, contents and methods of investigation

A.3.3.2 Implementation process of investigation

A.3.3.3 Results of investigation

A.3.4 Investigation on the status of marine bio-ecosystem

A.3.4.1 Scope, contents and methods of investigation

A.3.4.2 Implementation process of investigation

A.3.4.3 Results of investigation

A.3.5 Investigation on the status of hydrological connectivity in estuary

A.3.5.1 Scope, contents and methods of investigation

A.3.5.2 Implementation process of investigation

A.3.5.3 Results of investigation

A.3.6 Investigation on the status of ecological pressure in estuary

A.3.6.1 Scope, contents and methods of investigation

A.3.6.2 Implementation process of investigation

A.3.6.3 Results of investigation

A.4 Assessment of estuary ecosystem

A.4.1 General requirements

The specific methods of estuary ecosystem assessment shall be given. The damage situation of estuary coastal wetland, estuary habitat, estuary biological ecology, and estuary hydrological connectivity should be analyzed comprehensively to assess the damage degree of estuary ecosystem, with necessary figures and text description.

A.4.2 Assessment of coastal wetland

A.4.2.1 Assessment indicators and methods

A.4.2.2 Results of assessment

A.4.3 Assessment of estuarine habitat

A.4.3.1 Assessment indicators and methods

A.4.3.2 Results of assessment

A.4.4 Assessment of estuarine bio-ecosystem

A.4.4.1 Assessment indicators and methods

A.4.4.2 Results of assessment

A.4.5 Assessment of hydrological connectivity in estuary

A.4.5.1 Assessment indicators and methods

A.4.5.2 Results of assessment

A.4.6 Comprehensive assessment

A.4.6.1 Assessment indicators

A.4.6.2 Results of assessment

A.5 Assessment conclusion

A.5.1 General requirements

The assessment conclusions shall be clear and concise, and shall include findings on the status and the damage degree of ecosystems. The suggestions on the selection of key or priority areas of restoration are put forward, and the direction of the restoration is suggested.

A.5.2 Findings on the status of ecosystem

A.5.3 Assessment conclusion of the status of ecosystem

A.5.4 Countermeasures and suggestions

Annex B
(annex informative)
Ecological pressure factors of estuary ecosystem survey

A design of ecological pressure factors of estuary ecosystem survey is presented in Table B.1.

Table B.1 — Ecological pressure factors of estuary ecosystem survey

Page / pages

Investigation institution			
Investigation area			
Time of investigation	(yyyy-mm-dd)		
Investigation methods	<input type="checkbox"/> Literature reviewing.	<input type="checkbox"/> Field investigation	<input type="checkbox"/> others
Investigation content	Investigation indicators	Notes	
Runoff into the sea	Monthly freshwater inflows		
	Concentration of sediment in fresh water entering the sea		
Hydrological connectivity in estuary	Construction of sluices and dams in estuary; design and layout of fish passage facilities		
	Influence of dredging engineering in waterway		
Sewage effluents	Total amount of river pollutants; concentration of river pollutants		
	Situation of pollutants entering the sea at sewage outlets		
Human activities	Area, distribution, plane layout and other factors of coastal reclamation		
	Distribution, length and other factors of dykes and dams		
	Quantity, construction method and other factors of oil field		
	Type, method, area and other factors of breeding		
	Fishing method, species of fish caught, catch amount and other factors of marine fishing		

Investigator : Recorder : Proofreader: Reviewer:

Form-filling instructions:

1. The investigation methods may be single or multiple choices. Please fill the form according to actual conditions.
2. The detail information of each factor should be described on the attached pages as much as possible. Field survey results shall be submitted with the image material. The origination shall be indicated when quoting literature.