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China Association of Oceanic Engineering

Social Organization Standard

T/CAOE 20.7-2020

Technical guideline for investigation and assessment of coastal ecosystem —

Part 7:

Oyster reef

海岸带生态系统现状调查与评估技术导则 第 7 部分：牡蛎礁

（English Translation）

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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: *Mangrove*

——Part 4: *Salt marsh*

——Part 5: *Coral reef*

——Part 6: *Seagrass bed*

——Part 7: *Oyster reef*

——Part 8: *Sandy coast*

——Part 9: *Estuary*

——Part 10: *Bay*

This is part 7 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.*

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

This part was drafted by *Second Institute of Oceanography, Ministry of Natural Resources*; *Institute of Oceanology, Chinese Academy of Sciences*; *The Nature Conservancy*; *East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences*; *National Marine Hazard Mitigation Service*.

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Technical guidelines for investigation and assessment of coastal ecosystem —

Part 7: Oyster reef

1 Scope

This part of T/CAOE 20 specifies the general provision, survey content, survey methods, and ecological status assessment required for status survey of oyster reef ecosystems.

This document is applicable to investigation and assessment of coastal oyster reef ecosystem.

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, *Ocean survey specification* -- Part 2: Marine hydrology observation

GB/T12763.4, *Marine survey standard* -- Part 4: Marine chemical elements

GB/T 12763.6, 2007 *Ocean survey specification* -- Part 6: Marine biological survey

GB/T 12763.10, *Ocean survey specification* -- Part 10: Underwater topography survey

Birds HJ710.4, *Biodiversity observation technical guidance*

T/CAOE20. 1, *Technical guideline for investigation and assessment of coastal ecosystem* -- Part 1: General

3 Terminology and definition

The following terms and definitions apply to this document

3.1

oyster reef

an aggregated reef consisting of living oysters, shells of dead oysters, and other reef organisms that accumulated together

3.2

oyster reef ecosystem

whole system consisting organisms inhabit oyster reefs and the interchanging environment in the surrounding

3.3

oyster reef area

the total area occupied by oyster reef patches

3.4

oyster reef footprint

maximum areal extent encompassing one or more relatively concentrated oyster reef patches

3.5

oyster recruitment

the number of oyster spats (post-larval juvenile oyster) per unit area

4 General provisions

4.1 Work procedure

Working procedures are in accordance with the requirements prescribed by T/CAOE20. 1 Clause 5.

4.2 Quality control

Quality control is in accordance with the requirements prescribed by T/CAOE 20. 1 4. 3 in execution.

4.3 Survey protocol design

Survey design is in accordance with the requirements prescribed by T/CAOE20. 1 Clause 6.

4.4 Survey and evaluation report preparation

Investigation and assessment reports to be prepared are in accordance with the requirements prescribed by T/CAOE20. 1 Section 9. 1.

4.5 Data and results archiving

Data and results archive is in accordance with the requirements prescribed by the T/CAOE20. 1 Clause 10.

5 Status investigation content

Contents of oyster reef ecosystem investigation includes the oyster reef, biological communities, environmental factors and threat factors. The investigation contents, the factors, methods, and survey, are shown in Table 1. Survey content can be chosen according to the survey goal and assessment requirements.

Table 1 — Oyster reef ecosystem research contents and methods

Survey content	Metrics	Methodology	Survey method
Oyster reef	Reef: oyster reef patch area, reef height	Field investigation	See 6. 2. 1. 1
	Oysters: species, density, recruitment, shell height, tissue dry weight and shell dry weight	Field investigation	See 6. 2. 1. 2
Biological communities	Macrobenthos: species, density	Field investigation	According to GB/T 12763. 6-2007
	Phytoplankton: species, density		
Environmental factors	Water environment: water temperature, salinity, flow rate, dissolved oxygen and pH	Field investigation	Water temperature, salinity, flow rate measured according to GB/T 12763. 2. Dissolved oxygen, pH measured

			according to GB/T 12763. 4
	Sediment environment: sediment types		See 6. 2. 3. 2
Threats	Natural factors: predators, competitors	Existing information review Field investigation	See 6. 2. 4
	Anthropogenic factors: fishing, filter feeding bivalve aquaculture, marine engineering, developments, pollution	Existing information review Social investigation Field investigation	

6 Status survey method

6.1 Investigation requirements

6.1.1 Investigation area selection

The selection of investigation area should comply with the following principles:
a) collect historical data, and list oyster reef protected areas and historical natural oyster distribution areas as survey areas;
b) refer to previous project survey results, and take areas with a large number of oysters in benthic organism sampling as survey area;
c) interview coastal community and local fishermen, and take oyster wild-caught fishing areas, oyster aquaculture areas, and oyster spat-collection areas as survey areas;
d) conduct qualitative on-site investigations, in combination with diving sampling, and take areas where oyster distribution concentrates as survey area.

6.1.2 Cross-section and site layout

6.1.2.1 Cross-section layout

Cross-section layout should follow the following principles:
a) The cross-section should cover the entire area spatially, with a balanced layout that reflects the different ecological conditions of the oyster reef in the survey area;
b) If area is in intertidal zone, the direction of cross-section should be perpendicular to the coastline, and the relative location of the cross-section should be marked on land;
c) Each survey area should contain minimal 3 cross-sections, designed according to distribution area of the oyster reef.

6.1.2.2 Sample site layout

The sampling site layout should follow the following principles:
a) Sampling sites should distribute somewhat uniformly across the survey area, covering various directions and water depth.
b) If the survey area is in intertidal zone, then the sampling sites should be located across the intertidal slope to reflect varying elevations, usually 1 to 2 sites in the high intertidal area, 3 sites in the middle intertidal area, and 1 to 2 sites in the low intertidal area.
c) For survey areas in subtidal zone, uniform fixed-point grid-based sampling design should be adopted. The number of sampling sites is determined according to the area and distribution of the oyster reef patches. In principle, the distance between sampling sites should be greater than 1km. For oyster reef patches not covered by the cross-section, separate sampling site should be selected.

d) After determining the sampling site locations, the geographic coordinates of each site should be measured and recorded sequentially for long-term monitoring.

6.1.3 Investigation time and frequency

The investigation time depends on the species of oyster and the region of its distribution. In principle, investigation activities should be conducted twice a year, during the oyster spawning period (usually in late spring and early summer) and the end of the growing season of the year (usually in winter). The time for surveying oyster recruitment should be determined independently according to different oyster species, and should be arranged 3 months after the end of the oyster spawning peak.

6.2 Investigation method

6.2.1 Oyster Reef

6.2.1.1 Reef

6.2.1.1.1 Oyster reef patch area

In the intertidal zone, the area of each oyster reef patch can be determined by drone aerial photography or ranging wheel.

In the subtidal zone, sonar should be used to survey area of each oyster reef patch. The sonar survey should be performed in accordance with the requirements specified in GB/T 12763.10.

After the field investigation use GIS platform to process survey images, outline footprint of oyster reefs, and calculate the area of oyster reef patches.

6.2.1.1.2 Reef height

Reef height is the height of the reef relative to its surrounding bottom material, which should be measured along the direction of the reef ridge or the centerline of the long axis.

The height of oyster reefs in the intertidal zone should be measured manually. When the length of reef ridge is more than 200m, reef height should be measured once each 20m to 50m; When the length of reef ridge is no more than 200m, reef height should be measured once each 5m to 10m. The recording table for in-situ investigation is listed in Table A. 1.

The height of subtidal oyster reef is measured using multi-beam or single beam combined with side scan sonar, shallow formation profile and drilling verification. the detail method shall be implemented in accordance with the requirements specified in GB/T 12763. 10

6.2.1.2 Oyster

6.2.1.2.1 Sample collection

For each sampling site in intertidal zone, collect no less than 3 samples of 25cm×25cm quadrats, according to the requirements specified in Clause 12 of GB/T 12763. 6-2007.

For each sampling site in subtidal zone, perform survey by divers and collect no less than 3 samples of 25cm×25cm quadrats.

6.2.1.2.2 Species identification

Bring oyster samples back to the laboratory and identify the species based on the location, external morphology, internal anatomy, and molecular species diagnosis. Record results of investigation and analysis in Table A. 2.

6.2.1.2.3 Density

Count the number of live oysters in the plot and convert into number per unit area.

6.2.1.2.4 Recruitment

Live oysters (including juvenile oysters fixed on the shells of adult oysters) with a shell height of less than 20mm is counted in each quadrat, and then the data is transformed to the number per unit area. An alternative way is put 25cm×25cm hanging board before the peak breeding period and recovered them 3 months after the peak breeding period. The details method shall be carried out in accordance with the requirements of 13. 2. 1 in GB/T 12763. 6-2007.Recordresults of investigation and analysis in Table A. 2.

6.2.1.2.5 Shell height

At each station, shell height of each live oyster within a random quadrat is measured with a vernier caliper, and the size-frequency is analyzed using 5mm interval. Record results of the investigation and analysis in Table A. 2.

6.2.1.2.6 Tissue dry weight and shell dry weight

Randomly select 3 to 5 adult oysters from each quadrat. Upon shucking oyster, remove the soft tissue from shell and dry it to a constant weight, and weigh the dried tissue (g). Remove the biofouling species and impurities on the oyster shell, dry it to a constant weight, and weigh died shell (g). Record results of the investigation and analysis in Table A. 3.

6.2.2 Biological community

6.2.2.1 Macrobenthos

Species, abundance, and density of macrobenthos in the reef area to reflect biodiversity in the oyster reef area. Collect all macrobenthic organisms in the quadrat, identify species and count the number of individuals. In order to best represent species composition and minimize number of undetected species due to area limitations, collected additional benthic samples around each site for qualitative identification. The survey of macrobenthos in intertidal zone should be performed in accordance with the requirements specified in Clause 12 of GB/T 12763. 6-2007. The survey of macrobenthos in subtidal zone should be performed in accordance with the requirements specified in Clause 10 of GB/T 12763. 6-2007. Record results of the investigation and analysis in Table A. 4.

6.2.2.2 Phytoplankton

Investigate the species and density of phytoplankton. Investigation should be performed in accordance with the requirements specified in GB/T 12763. 6-2007.

6.2.3 Environmental factors

6.2.3.1 Water Environment

The investigation method of water temperature, salinity and flow rate should be performed in accordance with the requirements specified in GB/T 12763. 2. Record results of the investigation and analysis in Table A. 5.

The investigation method of dissolved oxygen and pH should be performed in accordance with the requirements specified in GB/T 12763. 4. Record results of the investigation and analysis in Table A.5.

6.2.3.2 Sediment environment

Determine bottom type on site, as hard substrate (rocks, reefs, concrete, etc.) or soft sediment (mud flats, muddy beaches, sandy beaches, etc.). Record results of the survey in Table A. 5.

6.2.4 Threat factors

6.2.4.1 Investigation method

Investigate threat factors by reviewing existing information, conducting social investigation, and on-site investigation. On-site survey of marine organisms should be performed in accordance with the requirements specified in GB/T 12763. 6-2007. On-site survey of bird species should be performed in accordance with the requirements specified in HJ 710. 4. Record results of the survey in Table A. 6.

6.2.4.2 Natural factors

6.2.4.2.1 Predator

Determine the species and number of oyster predators in the survey area, including fish species such as black sea bream, rays, mullet, and barracuda, carnivorous snails such as red snails and snails of Reishia genus, echinoderms such as starfish, and crustaceans such as mud crabs, and birds such as Eurasian oystercatchers.

6.2.4.2.2 Competitor

Determine the species and numbers of oyster competitors in the survey area, such as barnacles, blue mussels, Musculus senhousei, sea squirts, bryozoans, etc.

6.2.4.3 Anthropogenic Factors

6.2.4.3.1 Wild-caught oyster fishing

Know about whether there is fishing pressure for oysters in the survey area, and investigate the fishing method, season, frequency and catch.

6.2.4.3.2 Filter feeding shellfish aquaculture

Know about the species of filter-feeding shellfish cultured in the survey area, the aquaculture area, and the aquaculture season.

6.2.4.3.3 Ocean engineering/development

Understand whether there are large-scale infrastructures or buildings newly built in the survey area and the surrounding 3km, and the corresponding type and scale of such activities; and determine whether such activities occupied oyster reef area or caused sedimentation in the oyster reef area. If sediment accumulated in the oyster reef area is caused by such activities, then investigate thickness of soft sediment in comparison to surrounding bottom level with uniformly distributed sampling points. In areas of water depth not greater than 3m, the sediment thickness should be measured using meter stick. In areas of water depth greater than 3m, sub-bottom profiler should be used to measure sedimentation thickness, supplemented with verification by coring.

6.2.4.3.4 Pollution discharge

Know about whether there is land-based pollution discharge within the survey area and the surrounding 3km. If there are land-based pollution discharged, investigate the types, concentrations and amount of the pollutants.

7 Ecological status assessment

7.1 Evaluation index

The ecological status of oyster reef should be assessed from four aspects: oyster reef, biological community, environmental factors, and threat factors. The assessment and evaluation indexes are shown in Table 2.

Table 2—Evaluation index table of oyster reef ecological status

Evaluation content	Evaluate and evaluate indicators	Index explanation
Oyster reef	Oyster reef patch area/ (hm^2)※	Directly reflect the overall condition of the oyster reef
	Reef height /(m)※	
	Oyster species	Reflect oyster growth status and trend
	Oyster density/ (ind/m^2)※	
	Oyster recruitment /(ind/m^2)※	
	Proportion of adult oyster /(%)※	
	Oyster condition index	
	Size-frequency of live oyster shell height	
Biological communities	Species diversity of macrobenthos	Reflect biodiversity on oyster reef
	Phytoplankton species	Reflect abundance of food for oyster
	Phytoplankton density/ (ind/m^3)	
Environmental factors	Water temperature/ (℃)	Reflect physical and chemical environment determining habitat suitability for oysters growth
	Salinity	
	Dissolved Oxygen (DO) /(mg/L)	
	pH	
	Flow rate /(cm/s)	Reflects settlement condition for oyster larvae
	Sediment types	
Threat factors	Predator	Reflects the degree of natural factors affecting oyster reef
	Competitor	
	Fishing method, amount of catch	Reflect the impact of human activities on the oyster reef
	Species, culture area and periods of filter-feeding shellfish	
	Reef area occupied by marine engineering and development projects	
	Annual sedimentation thickness within reef area caused by marine engineering/development /(cm/a)	
	Types and concentrations of terrestrial-sourced pollution discharge	
NOTE ※ Indicates mandatory index for evaluation, others are additional evaluation indexes.		

7.2 Reference ecosystem

The reference ecosystem should be selected and used in the following ways:

a) Collect historical information of the survey region, including ecosystem data obtained from routine monitoring, independent investigation and literature, and establish reference ecosystem accordingly.

b) Establish reference ecosystem by prioritizing data that are representative and reflective of changes in the ecosystem.
c) When historical information is available and complete, then historical data should be used as the reference ecosystem for evaluation.
d) When historical information is partially complete, the available historical information should be used as the reference ecosystem for evaluation, complemented by descriptive evaluation of current conditions lacking historical data.
e) In the absence of historical information, ecological status assessment should be carried out without evaluation from comparing to reference ecosystem, and the results of the first assessment should be used as reference ecosystem for future assessments.

7.3 Evaluation method

7.3.1 Evaluation index calculation and status classification

7.3.1.1 Changes in oyster reef area

Change in area of oyster reef is the most important index that reflects the ecological status of oyster reef, and it is expressed as ratio of the present reef area of oyster reef to baseline value. The following is its formula (1):

$$\delta A = \frac{A - A_0}{A_0} \times 100\% \qquad \text{.....(1)}$$

where

δA Change in oyster reef area;

A Current oyster reef patch area, in square meters (m^2);

A_0 The baseline of oyster reef patch area, in square meters (m^2).

Table 3 shows the grade and score in change of oyster reef area change.

Table 3—Grading and evaluation table of change in oyster reef patch area

Grade	δA Range	Area Change	Evaluation Score (total value: 50)
I	$\delta A \geqslant -10\%$	Stable	50
II	$-50\% \leqslant \delta A < -10\%$	Decrease	25
III	$\delta A < -50\%$	Significantly decrease	0
NOTE In level I, if $10\% < \delta A \leqslant 50\%$ means that the area is increased and the score is assigned 75; if $\delta A > 50\%$ (aka. patch area significantly increased), then designate score of 100 points.			

7.3.1.2 Change in mean reef height

Change in mean reef height is among the main factors that reflect the damage or improvement of oyster reef, and it is expressed as ratio of the present height of oyster reef to baseline value. The following is its formula (2):

$$\delta \overline{H} = \frac{\overline{H} - \overline{H_0}}{\overline{H_0}} \times 100\% \qquad \text{.....(2)}$$

where

$\delta \overline{H}$ Change in mean reef height;

$\overline{H}$ the present height of oyster reef, in centimeters (cm);

$\overline{H_0}$ The baseline height of oyster reef, in centimeters (cm).

Table 4 shows the grading and evaluation score designation in change of mean reef height.

Table 4—Grade and score in change of mean oyster reef height

Grade	$\delta\overline{H}$ Range	Reef height change	Evaluation Score (total value: 50)
Ⅰ	$\delta\overline{H} \geqslant$-10%	Stable	25
Ⅱ	-50%$\leqslant \delta\overline{H} <$-10%	Decrease	12.5
Ⅲ	$\delta\overline{H} <$-50%	Significantly decrease	0
NOTE In level Ⅰ, if 10%$< \delta\overline{H} \leqslant$50% (aka. mean reef height increased), then designate score of 37.5; if $\delta\overline{H}$ >50% (aka. mean reef height increased significantly), then designate score of 50.			

7.3.1.3 Change in oyster density

Change in oyster density is the directly factors that reflects variations in oyster population, and it is expressed as ratio of the present oyster density to baseline value. The following is its formula (3):

$$D = \frac{\sum_1^n N_i}{0.25 \times 0.25n} \quad \text{.....(3)}$$

where

D The present oyster density, units: ind/m^2;

N_i Number of live oysters in ith quadrat;

n Total number of quadrat.

The calculation method of change in oyster density is shown in formula (4):

$$\delta D = \frac{D - D_0}{D_0} \times 100\% \quad \text{.....(4)}$$

where

δD Change in oyster density;

D_0 The baseline of oyster density, in units per square meter (ind/m^2).

Table 5 shows the grade and score in change of oyster density.

Table 5—Grading and score in change of oyster density.

Grade	δD Range	Oyster density variation	Evaluation Score (total value: 50)
Ⅰ	$\delta D \geqslant$-10%	Stable	25
Ⅱ	-50%$\leqslant \delta D <$-10%	Decrease	12.5
Ⅲ	$\delta D <$-50%	Significantly decrease	0
NOTE In level Ⅰ, if 10%$< \delta D \leqslant$50% (aka. oyster density increased), then designate score of 37.5; if δD>50% (aka. oyster density increased significantly), then designate score of 50.			

7.3.1.4 Changes in oyster recruitment

Change in oyster recruitment reflects the decrease or increase in oyster spat recruitment, and is an important factor that reflects whether oyster reef can-sustain itself or not. It is expressed as ratio of the present oyster recruit to baseline value.

The present oyster recruit is calculated as the formula (3).

The change in oyster recruitment is calculated as the formula (4).

Table 6 shows the grade and score in change of oyster recruitment.

Table 6—Grading and score in change of oyster recruitment.

Grade	δB Range	Changes in oyster recruitment	Evaluation Score (total value: 50)
Ⅰ	$\delta B \geqslant$-10%	Stable	50
Ⅱ	-50%$\leqslant \delta B <$-10%	Decrease	25
Ⅲ	$\delta B <$-50%	Significantly decrease	0
NOTE In level I, if 10%$< \delta B \leqslant$50% (aka. oyster recruitment increased), then designate score of 75; If $\delta B >$50% (aka oyster recruitment increased significantly), then designate score of 100.			

7.3.1.5 Change in proportion of adult oyster

The percentage of adult oyster can reflect the survival of oysters in past several years, and its change can assess whether oyster population has suffered a sudden mass death recently and whether there is a large-scale oyster fishing, etc. The change in percentage of adult oyster is expressed as ratio of the present percentage of adult oysters to baseline value.

Number of adult oysters: the number of marketable-sized oysters in a sample.

The calculation method of proportion of adult oyster is shown in formula (5):

$$M = \frac{\sum_{i=1}^{n} \frac{NM_i}{NT_i}}{n} \times 100\% \qquad \text{.....(5)}$$

where

M The present percentage of of adult oyster;

NM_i Number of adult oysters in quadrat i;

NT_i Total number of oysters in quadrat i;

n The number of quadrats.

The change in percentage of adult oyster is calculated as the Formula (6):

$$\delta M = \frac{M - M_0}{M_0} \times 100\% \qquad \text{.....(6)}$$

where

δM Change in percentage of adult oyster;

M_0 The baseline percentage of adult oyster.

The status grade and evaluation score designation of change in proportion of adult oyster are shown in Table 7.

Table 7—Grade and score in change of percentage of adult oyster

Grade	δM Range	Change in Percentage of Adult Oyster	Evaluation Score (total value: 50)
Ⅰ	$\delta M \geqslant$-10%	Stable	25

II	$-50\% \leqslant \delta M < -10\%$	Decrease	12. 5
III	$\delta M < -50\%$	Significantly decrease	0
NOTE In level I, if $10\% < \delta M \leqslant 50\%$ (aka. proportion of adult oysters increased), then designate score of 37.5;if $\delta M > 50\%$, (aka. proportion of adult oysters increased significantly), then designate score of 50.			

7.3.2 Comprehensive assessment of oyster reef ecological status

The comprehensive assessment of ecological status of oyster reef is conducted based on the assignment scores in the changes of oyster reef area, reef height, oyster density, oyster recruitment and percentage of adult oyster. The result of the comprehensive assessment was calculated as the Formula (7).:

$$V = \frac{\sum_{i=1}^{n} V_i}{\sum_{i=1}^{n} V_{iMAX}} \quad \text{.....(7)}$$

where

V Results of oyster reef ecological status assessment;

V_i The score of the i^{th} index used in the comprehensive assessment, $i \leqslant 5$;

V_{iMAX} Total score of metric i, $i \leqslant 5$.

In the case where a particular assessment metric cannot be evaluated due to lack of current data or reference value, disregard this metric and calculate final status assessment value with the evaluation scores and total scores of the remaining metrics that have available data.

The ecological status grade of oyster reefs is shown in Table 8.

Table 8—Grade table of assessment results of oyster reef ecological status

Grade	V Range	Ecological Status
I	$V \geqslant 50\%$	Stable
II	$25\% \leqslant V < 50\%$	Damaged
III	$V < 25\%$	Severely damaged

For evaluation indexes not included in the above quantitative assessment, single-factor, qualitative evaluation should be performed given adequate information. For additional evaluation indexes calculation and score designation methods, please refer to Annex B. In the investigation report, considering both results of the above comprehensive assessment of oyster reef ecological status and these additional qualitative evaluation metrics, analyze internal and external drivers for changes in oyster reef ecological condition, and propose corresponding management measures (Table 9).

Table 9—Classification description of oyster reef ecological status assessment results and corresponding management measures

Classification	Classification description	Management measure
I	The oyster reef is generally stable and self-sustaining	regular monitoring and continuous management
II	The oyster reef is degraded, but the basic structure still remains, with reduced ability to recovery naturally	Strengthen ecological management, control threat factors, and facilitate natural recovery of ecosystems

III	The oyster reef is seriously damaged, with basic structure lost and recovery ability significantly reduced	Strengthen ecological management, control threat factors, and interfere with artificial restoration activities to improve ecosystem conditions

Annex A
(annex normative)
Record of investigation elements of oyster reef

Table A. 1～Table A. 6 are field survey record sheets for each survey element of oyster reef.

Table A. 1—Field survey record sheet for oyster reef height

Total page NO. page

Sea area Geographic name Survey time Reefs area ___ m^2 Reef ridge length Investigation method			
Sample location	Longitude	Latitude	Height/(cm)

Measure Record Proofread

Table A. 2—Oyster shell height, density and recruitment survey record

Total page NO. page

Sea area Site # Investigation method □Quadrat □Settlement plate Species of oysters Sampling date Determination date										
Quadrat / settlement plate #	The total number of oyster /(ind)	Number of individuals per oyster shells height category ind							Oyster density /(ind/m^2)	Oyster recruitment /(ind/m^2)
		0to5mm	5mmto10mm	10mmto15mm	15mmto20mm	20mmto25mm	25mmto30mm	.....		

Investigate Measure Calculate Proofread

Table A. 3—Oyster wet weight and dry weight measurement record

Total page NO. page

Sea area	Site #	Sampling date	Measurement date		
Quadrat #	Individual oyster sample #	Species	Tissue dry weight g	Shell dry weight g	Condition index

Sampling Measure Calculate Proofread

Table A. 4—Macrobenthos Sampling Record

Total page NO. page

Sea area	Site	Quadrat #	Sample thickness	Sampling time
NO.	Species name	Number of individual /(ind)	Density /(ind/m^2)	Remark

Sampling Measure Calculate Proofread

Table A. 5—Oyster reef basic environmental factor survey

Sea area to	Monitoring time (DD/MM/YYYY)	to	(DD/MM/YYYY)	Analysis time						
Station	Longitude	Latitude	Date	Time	Sampling depth /(m)	Water temperature/ (℃)	Salinity	DO (Dissolved Oxygen) /(mg/L)	pH	Bottom types	Flow rate /(cm/s)

Investigate Record Proofreader

Table A. 6—Threat Factor Investigation Record

Total page NO. page

Sea area Research area Investigation method

Investigation time to (DD/MM/YYYY)

Threat factors	Description	Data source and No.
Predator		
Competitor		
Oyster fishing		
Filter-feeding shellfish aquaculture		
Marine engineering/development		
Land-based pollution discharge		
Other human activities		
Note: If the form is not enough, additional pages can be attached.		

Investigate Record Proofread

Annex B
(annex informative)
Additional evaluation index and method

B.1 Oyster condition index

The oyster condition index (CI) is calculated according to formula (B. 1):

$$CI = \frac{FT}{FS} \times 100\% \quad \text{.....(B.1)}$$

where

CI Condition index;

FT Tissue dry weight, in grams (g);

FS Shell dry weight, in grams (g).

B.2 Live oyster shell height frequency distribution

For each quadrat, group oyster shell height every 5mm and count the number of oyster individuals in each size category. Calculate the oyster density of each size category according to 7.3.1.3 formula (3) in this document. Plot histogram with shell height on the x-axis and mean density of each oyster size category group as the y-axis, example as shown in Figure B. 1.

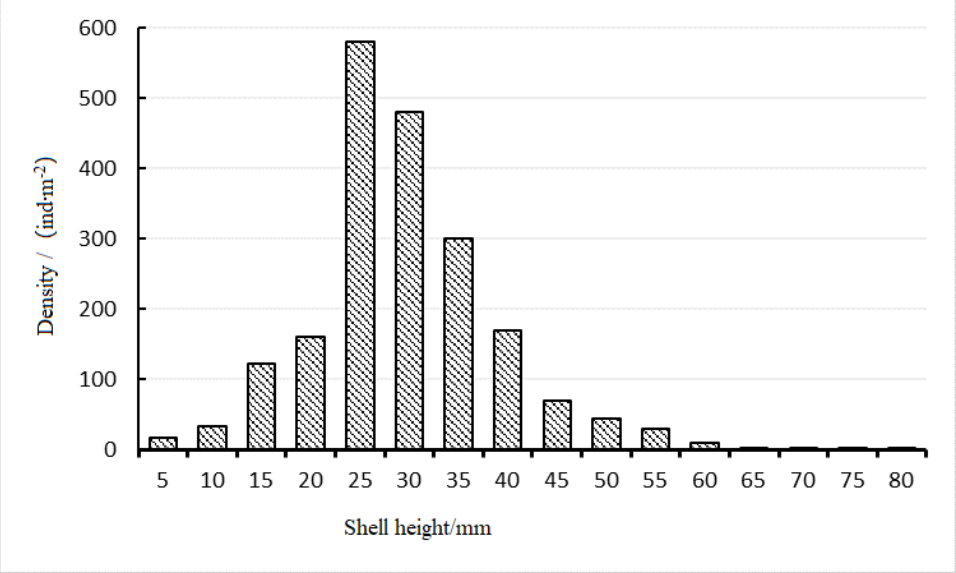

Figure B. 1 Frequency distribution example of oyster shell height

B.3 Macro Assessment Biodiversity Index

The evaluation of macrobenthic biodiversity index (Shannon-Wiener diversity index) is calculated according to formula (B. 2):

$$H' = -\sum_{i=1}^{S} P_i \ln P_i \quad \text{.....(B.2)}$$

where

H' Species diversity index;

S Species richness;

P_i Number of individuals in species i divided by total number of individuals of all species at a particular sampling site.

References

[1] Baggett, L. P., Powers, S. P., Brumbaugh, R., Coen, L. D., DeAngelis, B., Green, J., Hancock, B., Morlock, S., 2014. Oyster habitat restoration monitoring and assessment handbook. The Nature Conservancy, Arlington, VA, USA. 96 pp.