INTRODUCTION
Introduction to the Biological Assessment of the Yellow Sea Ecoregion and an Overview of its Results

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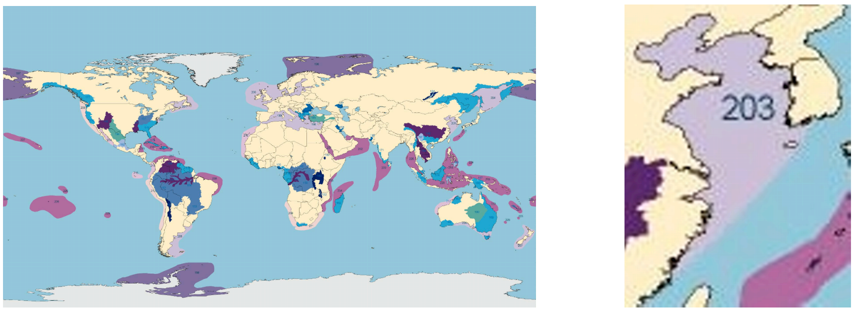
INTRODUCTION

The Yellow Sea Ecoregion Biological Assessment Report documents the results of a set of biological assessments conducted by the Yellow Sea Ecoregion Planning Programme (YSEPP), an international partnership between WWF, the Korea Ocean Research and Development Institute (KORDI) and the Korea Environment Institute (KEI). Biological assessment was part of a biodiversity conservation planning process for the Yellow Sea Ecoregion, and the assessment was successful in providing compiled data for the next step in the planning process, which was the Priority Area Analysis. This report should be read as a background document for the Yellow Sea Ecoregion Priority Area Analysis report.

Global significance of the Yellow Sea Ecoregion

The Yellow Sea Ecoregion (203) is a marine ecoregion listed in the Global 200 ecoregions, a comprehensive listing of globally significant large ecosystem units (Olson 2002). The Yellow Sea Ecoregion is globally significant because it is a marine ecosystem representative of the temperate shelf sea Major Habitat Type in the Indo-Pacific marine realm (Olson 2002) (Fig. 1). The Yellow Sea Ecoregion is defined as the area of shallow continental shelf sea that includes the Bohai Sea, the Yellow Sea and the East China Sea (Olson 2000, Olson 2002). China, the Democratic People's Republic of Korea and the Republic of Korea are coastal states of the Yellow Sea Ecoregion and Japan has been a traditional user of the fishery resources of this ecoregion. This large area of the continental shelf sea is also listed in the Large Marine Ecosystems (LMEs) (Fig. 2) (Sherman 1999). The LMEs includes 64 marine ecosystems globally with the combined area of the Yellow Sea LME (LME #48) and the East China Sea LME (LME #47) approximately corresponding to the area of the Yellow Sea Ecoregion discussed here.



(Left) Global 200 Marine Ecoregions (Right) Yellow Sea Ecoregion (203)

Fig. 1 Global 200 Marine Ecoregions and Yellow Sea Ecoregion

(Left) Large Marine Ecosystems of the world (Right) Yellow Sea LME 48 and East China Sea LME 47

Fig. 2 Large Marine Ecosystems (LMEs) in the world and the Yellow Sea LME

Biodiversity conservation and ecoregion planning

It is required that biodiversity conservation be based on scientific principles. In order to achieve biodiversity conservation in the long-term, four goals need to be incorporated in the planning (Noss 1991). Theses goals are: 1) represent all native ecosystem types in a system of protected areas; 2) maintain viable populations of all native species; 3) maintain ecological and evolutionary processes such as hydrological processes and nutrient cycles; and 4) maintain areas of natural habitats that are large enough to be resilient to disturbance (Fig. 3).

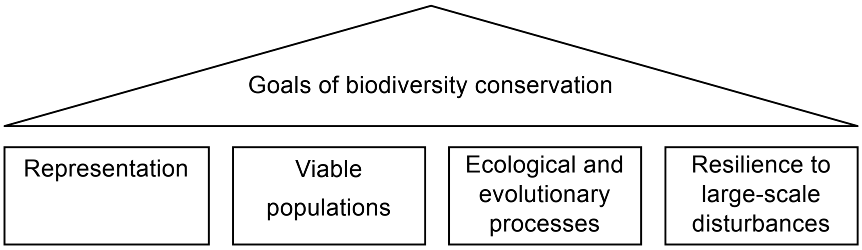


Fig. 3: Four goals of biodiversity conservation

There is another critical aspect in conservation planning: planning for a system of protected areas. Creating a system of protected areas is one of the extremely important response options for biodiversity conservation (Millennium Ecosystem Assessment Biodiversity Synthesis 2005).

There are several distinctive frameworks for a system of protected areas (Whittaker et al. 2005). Two widely advocated frameworks are the Representation Framework and Important Area Framework. The representational approach aims at identifying representative examples of ecosystem types or habitat types that are present in bio-geographic or ecological systems, while the Important Area approach chooses species-based parameters and then a set of criteria is determined to identify areas that are important to chosen species (Table 1).

Table 1: Planning frameworks for protected areas (modified from Whittaker et al. (2005))

PLANNING FRAMEWORK	REPRESENTATION	IMPORTANT AREAS
Basic idea	An example of each type	A set of sites that together protect key attributes of concern
Questions arising	What are the units/types of nature? What do we add next?	What are the key attributes and how can they be assessed?
Parameters	Vegetation formations Faunal regions Ecoregions	Threatened species Endemic species Species assemblages Congregating species
Methods	% dissimilarity Controlling factors	Application of varied criteria

Ecoregion planning is a biodiversity conservation planning methodology that aims at integrating above mentioned biodiversity goals and planning frameworks. This planning approach combines both the

Representation Framework and Important Area Framework and aims to produce one integrated planning output: a biodiversity vision (Fig. 4). The biodiversity vision has distinctive characteristics of systematic conservation planning (Margules 2000): 1) it makes clear choices about the features used in the planning, which are surrogates for overall biodiversity and 2) it sets explicit goals in the form of quantitative targets for conservation goals.

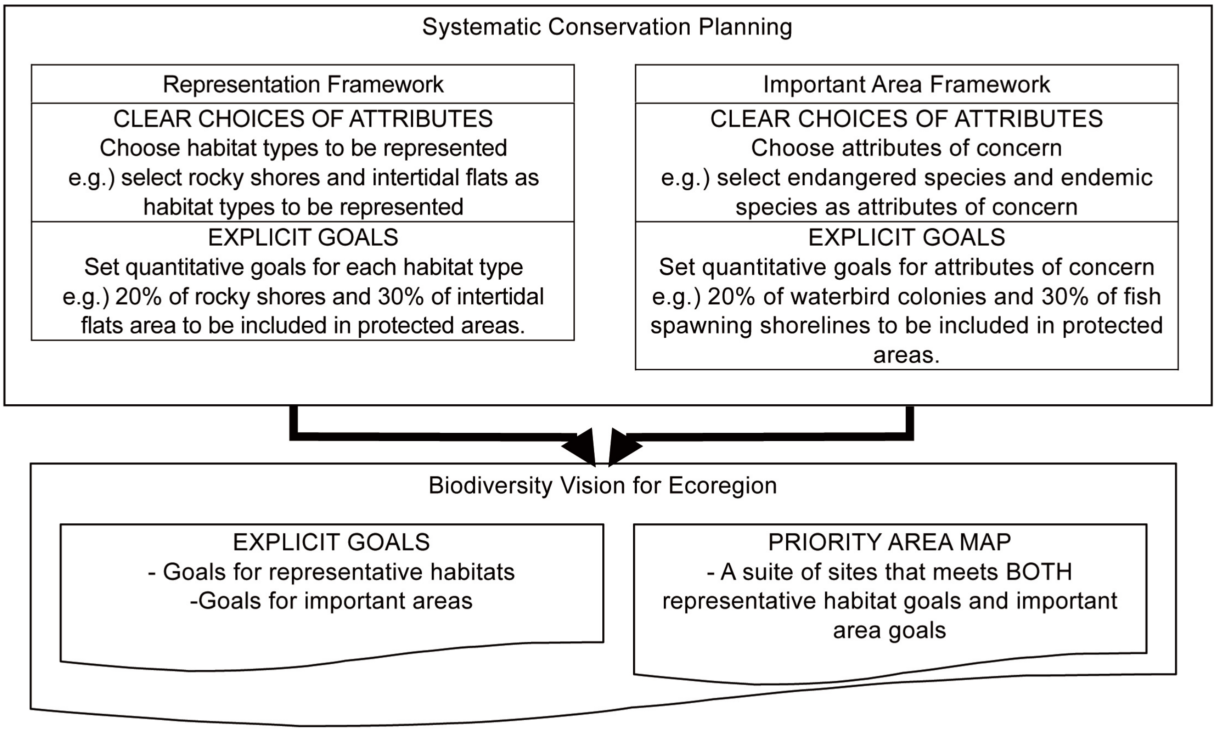


Fig. 4 Ecoregion planning integrates both representation and important area frameworks into one planning output – the biodiversity vision

Adaptive planning for the Yellow Sea Ecoregion

The ecoregion planning process can be divided into three operational stages: 1) the reconnaissance stage 2) the biodiversity vision stage and 3) the conservation strategy and action plan development stage (Fig. 5).

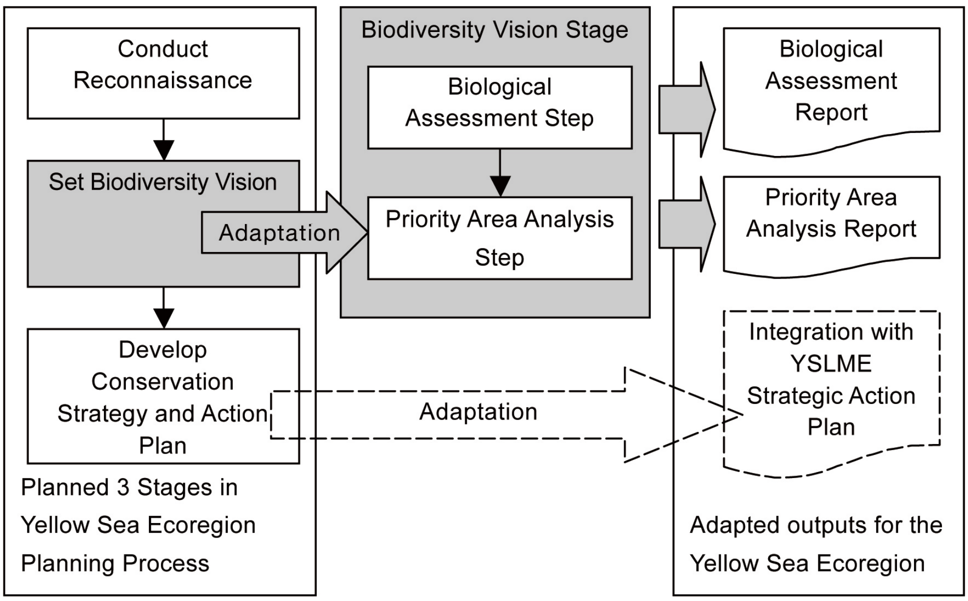


Fig. 5 Adapted ecoregion planning process and outputs for the Yellow Sea Ecoregion

The reconnaissance stage is a scoping stage to preliminarily identify attributes of concern in the ecoregion such as what habitat types and species need more attention for overall biodiversity conservation. The biodiversity vision stage is to make clear choices of attributes, to map out data on the chosen attributes and to select a suite of sites that meet explicit goals. In the final stage, conservation strategy and action plans, which define management goals and actions, are developed in order to achieve explicit long-term goals.

However, the ecoregion planning process requires an adaptive approach mainly for two reasons. Firstly, the availability or lack of data on certain attributes of concern affects the degree of technical application of the biodiversity vision methodology. Second, the success of the conservation strategy and action plan stage depends as much on political acceptance by key stakeholders as much as it does on the technical quality of the strategy and the plan.
In the case of the Yellow Sea Ecoregion's planning, the biodiversity vision stage was adapted by dividing into two steps: the biological assessment step and the priority area analysis step. This was in recognition of a finding in the reconnaissance stage that a fair amount of scientific data, including mapping information, was available on attributes of concern of the Yellow Sea Ecoregion. It was thus decided that the results of the biological assessment would be published as an independent report for its own sake.

The conservation strategy and action plan stage was also adapted to integrate the results of the biodiversity vision stage into another ecosystem management project, the UNDP/GEF Yellow Sea Large Marine Ecosystem Project (YSLME). Because both the YSLME project and the Yellow Sea Ecoregion Planning project were planning a similar biodiversity conservation orientated output, integrating the biodiversity vision into one regional biodiversity conservation plan made more sense. A memorandum of understanding on cooperation was signed between the two projects to ensure such integration.

METHODS OF BIOLOGICAL ASSESSMENT
Biological assessment is part of a larger process of ecoregion planning (Abell 2002) (WWF International 2004). This section explains the specific methods of the biological assessment applied to the Yellow Sea Ecoregion.

Clear choices of attributes through setting common criteria
Firstly, common criteria were set in order to make clear choices of attributes of concern and habitat types in the Yellow Sea Ecoregion for the important area (Fig. 6).

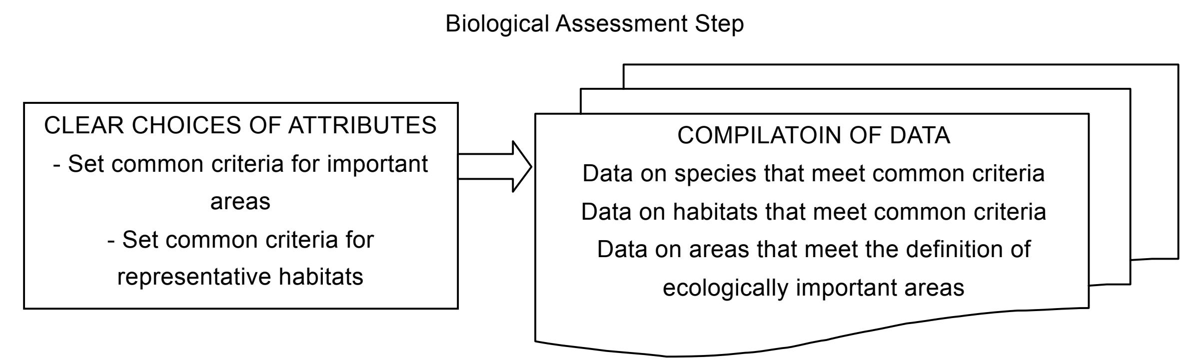


Fig. 6 Biological Assessment Step for the Yellow Sea Ecoregion

The common criteria are a set of attributes that were used in the biological assessment and are common within the same taxonomic group. Since the Yellow Sea Ecoregion is an international ecoregion, these common criteria are necessary in order to standardise clear choices of attributes and compile data across different countries.

Developing common criteria for biological assessment
A draft of common criteria for biological assessment was prepared by the Planning Team of the Yellow Sea Ecoregion Planning Programme. This Planning Team was a secretariat for planning programme's implementation. The draft selection of criteria was based on previous marine ecoregion planning exercises for the Bering Sea Ecoregion (Banks 1999), Sulu-Sulawesi Marine Ecoregion (Cabanban 2001), and the Fiji Islands Marine Ecoregion (Wilson et al., 2005). The selection of six taxonomic groups of animal and plant species (mammal, bird, fish, mollusc, coastal plant, and algae) were based on the selection of important biodiversity features in the reconnaissance reports of the Yellow Sea Ecoregion (Yuan et al. 2001) (Moores

et al.2001) and on examples of attributes used in ecoregion planning for the Bering Sea, Sulu-Sulawesi and Fiji marine ecoregions.

The draft of common criteria contains six criteria: Criterion 1: Representative species and habitat types; Criterion 2: Endemism and unique species assemblages; Criterion 3: Species richness; Criterion 4: Species of special concern; Criterion 5: Commercially important species; and Criterion 6: Intact habitat and ecological processes (Fig. 7).

Representation Framework	Important Area Framework
CLEAR CHOICES OF ATTRIBUTES (attributes = habitat types to be represented) <u>DRAFT COMMON CRITERIA</u> Criterion 1: Representative species and habitat types	CLEAR CHOICES OF ATTRIBUTES (attributes of concern) <u>DRAFT COMMON CRITERIA</u> Criterion 1: Representative species and habitat types, Criterion 2: Endemism and unique species assemblages, Criterion 3: Species richness, Criterion 4: Species of special concern, Criterion 5: Commercially important species, Criterion 6: intact habitat and ecological processes

Fig. 7 Setting common criteria for Representation Framework and Important Area Framework

In order to clarify the definitions of criteria, further explanations were given where deemed necessary. Under Criterion 2, the geographic scope of endemism was defined as endemic to the area of the Bohai Sea, Yellow Sea and East China Sea. Under Criterion 3, the definition of “species of special concern” included threatened species that are either listed in the IUCN Red List, national equivalents of the IUCN Red List, and/or depleted fishery stocks of aquatic species.

Review and adoption of common criteria by regional experts
The YSEPP formed the Biological Assessment Working Group with the participation of scientists from China, the Republic of Korea and Japan who were experts on the major taxonomic groups in the Yellow Sea Ecoregion (mammal, bird, fish, mollusc, coastal plant and algae).
The member scientists of the working group reviewed the draft of common criteria in the Preparatory Workshop for the Yellow Sea Ecoregion Biodiversity Vision held in the Republic of Korea in 2004. The scientists formed sub-groups to represent each taxonomic group and each sub-group then examined the applicability of the draft of common criteria to their specific taxonomic group. The scientists also considered additional criteria in order to identify species and ecological processes that are important for biodiversity conservation. Some sub-groups agreed to adopt additional criteria which are documented in the overview section of this paper.

Compilation of data according to clear choices of attributes
Once clear choices of attributes were made by adopting the common criteria, data was compiled on species that met the common criteria, habitats that met common criteria and areas that met the definition of ecologically important areas.

Compilation of Indicator Species and ecologically important areas
The scientists defined species that met the common criteria as Indicator Species. In the case of those Indicator Species that are characteristic of specific habitat types, such as a species of eelgrass (*Zostera marina*) which is characteristic of the sea grass habitat, these species were not only considered as choices of attributes for important areas, but also for representative habitats.

The scientists defined the habitats critical for conservation of the Indicator Species and/or areas that met other common criteria such as Criterion 6: Intact habitat/ecological processes, as ecologically important areas. These areas are important for certain attributes. Based on these definitions, ecologically important areas were listed by the individual Taxonomic Sub-groups of scientists.

Part of the listing was done during the preparatory workshop, and the rest was completed as individual biological assessment papers.

Other considerations in biological assessment
Review of bio-geographic sub-regions was conducted by each Taxonomic Sub-group. This was necessary in the application of the representation framework since, if the ecoregion contains very distinctive bio-geographic sub-regions, additional samples of the same habitat type must be added from each of the different bio-geographic sub-regions. Species assemblages in the same habitat type are likely to be different if they are located in different bio-geographic sub-regions. This will later affect representation analysis of species assemblages and regional-scale habitat types in the Priority Area Analysis later. For example, in the assessment of the Bering Sea Ecoregion, experts divided the ecoregion into five sub-regions according to the formation of the continental shelf, sea basin, influence of sea ice and sea currents (Banks, D. et al. 1999).

Knowledge gaps in the ecology of individual taxonomic groups, threats to their conservation, and relevant studies needed to fill these knowledge gaps were examined by the respective Taxonomic Sub-groups of scientists. Ecological threats in this assessment were defined as both direct and indirect causes for reduction and deterioration of native species and habitats.

OVERVIEW OF BIOLOGICAL ASSESSMENT RESULTS

This section covers consolidated results of the biological assessment. For the results of individual taxonomic groups, please refer to the chapter: “Biological Assessment Papers”.

Two major results
There were two types of major results from this biological assessment. First was that clear choices of attributes for important areas and representative habitats. Second was the data compilation according to the selected choices of attributes.

Results 1: Determined choices of attributes for important areas and representative habitats

Six sets of adopted common criteria as clear choices of attributes
Six sets of the common criteria were adopted by each of the six Taxonomic Sub-groups (Table 2). Each of the six Taxonomic Sub-groups adopted different sets of common criteria. Criteria that more than three Taxonomic Sub-groups adopted were: Criterion 1 (representative species/ habitat), Criterion 2 (endemism), Criterion 4 (species of special concern) and Criterion 5 (commercially important species). Criterion 3 (species richness) was adopted only by the mollusc group. Additional criteria were adopted as follows: the Ramsar criteria on waterbirds (bird group), a criterion on species in which early maturation was observed (fish group) and a criterion on scientific importance (coastal plant group).

Table 2 common criteria adopted by the six Taxonomic Sub-groups

Adopted Criteria by six Taxonomic Groups	Mammal	Bird	Fish	Mollusc	Coastal plant [1]	Algae
Criterion 1: representative species / habitat	**X**	**X**	**X**	**X**	**X**	**X**
Criterion 2: endemism	**X**		**X**	**X**	**X** [2]	**X**
Criterion 3: species richness				**X** [3]		
Criterion 4: species of special concern	**X**	**X**	**X**	**X**	**X**	**X**
Criterion 5: commercially important species			**X**	**X**	**X** [4]	**X**
Criterion 6: intact habitat	**X** [5]	**X** [5]		**X**		
Additional criterion		**X**	**X**		**X**	

Notes:
X indicates the criterion adopted by the corresponding taxonomic group.
1: for the Republic of Korea, the biological assessment was done on halophytes.
2: no applicable species in the Republic of Korea.
3: comprehensive data not available in China
4: no applicable species in the Republic of Korea.
5: applicable to the Republic of Korea only.

Definition of ecologically important areas as determined choices of attributes
Ecologically important areas for the Indicator Species were defined as: breeding/spawning areas (mammal, bird, and fish groups), migration routes or stopover sites (mammal and bird groups), wintering grounds (bird and fish groups), distribution of species of special concern (all six groups), particular types of habitats preferred by the Indicator Species such as inter-tidal flat or sandy beaches (fish, coastal plant, and mollusc groups), major areas of distribution (mammal and algae groups) and intact habitats protected from fishing and other human activities (mammal group).

Results 2: Compiled data according to clear choices of attributes
Selected Indicator Species as compiled data
In total, 129 Indicator Species were selected from six taxonomic groups (Table 3).

Table 3 Number of Indicator Species by Taxonomic Group

Taxonomic Group	Mammal	Bird	Fish	Mollusc	Coastal plant	Algae	**Total**
No. of selected Indicator Species	4 spp.	14 spp.	38 spp.	30 spp.	20 spp.	23 spp.	**129 spp.**

The number of species selected under Criterion 1 (Endemism) was 25. Although some of these species were not strictly endemic at the species level to the Yellow Sea Ecoregion, they were selected because they were considered to be isolated populations and stocks by the mammal and fish Taxonomic Sub-groups. This isolation was caused by changes in the direction of ocean currents between the East China Sea and the Sea of Japan/ East Sea after the last glacial period ended (Kobayashi 1993).

Under Criterion 4 (Species of Special Concern), 50 species were selected. All of the six Taxonomic Subgroups selected at least two species under this criterion. The fish taxonomic group had the highest number of species listed (19 spp.) followed by the bird group (12 spp.).

For Criterion 5 (commercially important species), 58 species were selected. The fish taxonomic group (30 spp.) accounted for more than a half of the total, followed by the coastal mollusc taxonomic group (15 spp.) , with the algae taxonomic group (10 spp.) the third largest. None of the species were selected under this criterion from the mammal and bird taxonomic groups.

Mapped ecologically important areas as compiled data
In total, 146 sets of maps of ecologically important areas for the Indicator Species were selected (Table 4). In principle, the total number of the maps corresponds to the number of Indicator Species. However, there were exceptions to this one-to-one match between maps and Indicator Species. For some Indicator Species, scientists from different countries provided different maps for the same species, thus increased the number of maps more than that of the Indicator Species. For other species, no scientists from any country were able to provide any maps due to lack of mapping data and knowledge, thus reducing the number of maps to less than that of the Indicator Species.

Table 4 The number of maps of ecologically important areas for Indicator Species by the Taxonomic Groups.

Taxonomic Group	Mammal	Bird	Fish	Mollusc	Coastal plant	Algae	**Total**
China BA papers*	3	10	8	14	15	13	**63**
Korea BA papers*	4	13	23	16	3	17	**76**
Japan BA papers*	n/a	n/a	7	n/a	n/a	n/a	**7**

* BA papers: Biological assessment papers
n/a: Not applicable.

The total numbers of ecologically important areas determined were: 64 based on the China biological assessment papers, 107 by the Korea biological assessment papers, and 15 by the Japan biological assessment paper (Table 5). Only when the same area name was given to ecologically important areas of different Indicator Species within the same taxonomic group, was it counted as the same ecologically important area. Issues of partial overlaps and/or inclusions within and across taxonomic groups were not considered at this stage of biological assessment.

Table 5 Number of ecologically important areas

Taxonomic Group	Mammal	Bird	Fish	Mollusc	Coastal plant	Algae	**Total**
China BA papers*	3	16	17	12	14	2	**64**
Korea BA papers*	4	26	17	42	12	6	**107**
Japan BA papers*	n/a	n/a	15	N/a	n/a	n/a	**15**

* BA papers: Biological assessment papers
n/a: Not applicable.

A summary of the results from the biological assessment for the Yellow Sea Ecoregion is given in figure 8.

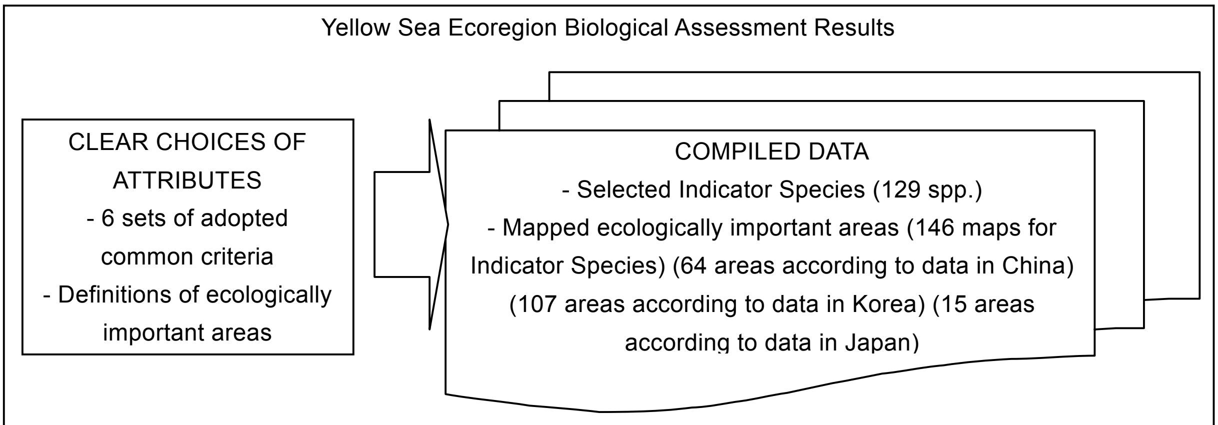


Fig. 8 Summary of Biological Assessment Results for Yellow Sea Ecoregion

DISCUSSION

ADEQUACY OF BIOLOIGICAL ASSESSMENT: APPLICATION OF THE IMPORTANT AREA FRAMEWORK AND THE REPRESENTATION FRAMEWORK

Since ecoregion planning aims at integrating both the Important Area Framework and the Representation Framework into one biodiversity vision, at this step it is useful to examine how these two frameworks were applied in practice in the biological assessment of the Yellow Sea Ecoregion.

Application of the Important Area Framework

The choices of attributes of concern for the Yellow Sea Ecoregion were broad and comprehensive as summarised in the results. Not only did the choices included commonly used endangered species and their habitats by all six Taxonomic Subgroups, but also four out of six Taxonomic Subgroups deliberately chose to include commercially important species and their key habitats. This choice means that the final selection of priority areas can incorporate considerations on maintenance of ecosystem's provisioning services of the Yellow Sea Ecoregion because the conservation of key habitats, such as the spawning grounds of commercially important fishery species can help maintain such provisioning services (fish catches) from fisheries.

Application of the Representation Framework

The application of the Representation Framework to the Yellow Sea Ecoregion was not as comprehensive and systematic as the Important Area Framework. An attempt to list habitat types to be represented was made using the criteria on representative species and habitat types, but it did not produce a complete list of all relevant habitat types that are present in the Yellow Sea Ecoregion. For example, coastal brackish/ saline lagoons exist in the ecoregion, but it was not selected by any Taxonomic Subgroups.

However, most of the other marine and coastal wetland types were selected through the adoption of Indicator Species that are characteristic of specific habitat types in criterion 1. For instance, adoption of a sea grass species, *Zostera marina* as an Indicator Species and the inclusion of their major distributions in ecologically important areas has the same results as selecting the sea grass bed habitat as a habitat type to be represented. This use of a characteristic species and its relation to the selection of habitat types should be further examined in the following Priority Area Analysis.

ADEQUACY OF BIOLOGICAL ASSESSMENT: FROM GENERAL PLANNING POINTS OF VIEW

The adequacy of the biological assessment was also reviewed from three general planning points of view: 1) preparation for the Priority Area Analysis, 2) trans-boundary assessment, and 3) multi-taxa assessment. Needs for further improvements were also discussed.

Biological assessment papers from each country were significant sources of information for deciding clear choices of attributes and data compilation. Review of these papers by experts was a significant endeavour. However, it should be noted that there was a discrepancy in the scale of available data between China and Korea. This discrepancy affected the adequacy of the integration (overlaying) of ecologically important area maps for each taxonomic group when Potential Priority Areas were identified in the following analysis. Therefore, adequacy of biological assessment needs to be revisited in the discussion of the Priority Area Analysis and its results, the Potential Priority Area maps.

Preparation for the Priority Area Analysis
The biological assessment was part of a bigger process in identifying priority areas for biodiversity conservation at the ecoregion scale. In the biological assessment of Yellow Sea Ecoregion, the assessment produced adequate datasets from the following two viewpoints, thus completing the assessment successfully.

Trans-boundary assessment
It was the first time to complete a trans-boundary biodiversity assessment in the Yellow Sea Ecoregion, which is a trans-boundary marine ecosystem that spreads across China, the Democratic People's Republic of Korea and the Republic of Korea. The biological assessment was able to compile data from two of the three coastal countries (China and the Republic of Korea) and from Japan that had extensive fisheries data dating from 1950's and 60's, which assisted in conducting a trans-boundary assessment.
Despite the fact that it was not possible for the YSEPP project to involve scientists from the Democratic People's Republic of Korea, which left some information gaps, this lack of data should not obscure the significance of this assessment since a trans-boundary assessment of this multi-taxa type has never been conducted for this region.

Multi-taxa assessment
The assessment covered a wide range of major taxonomic groups (mammal, bird, fish, mollusc, coastal plant and algae) in the Yellow Sea Ecoregion ecosystem including 129 Indicator Species and 146 maps of ecologically important areas.
It is of note that four of the Taxonomic Subgroups adopted the Commercially Important Species Criterion and this indicates that a wide range of taxa have significant economic value to the societies around the Yellow Sea Ecoregion.

Necessity of Further Prioritisation
The biological assessment revealed that there were 64, 107 and 15 ecologically important areas according to data in China, the Republic of Korea and Japan respectively. These findings presented a necessity for further prioritisation in order to identify fewer numbers of areas that are indispensable and have higher priority for conservation actions.

Major knowledge gaps
The authors of the biological assessment papers identified two levels of major knowledge gaps: 1) lack of specific knowledge on selected Indicator Species and 2) lack of general knowledge on the taxonomic groups.

Specific knowledge gaps on Indicator Species
Specific knowledge gaps on ecologically important areas were identified for all the Taxonomic Groups, namely lack of mapping data on ecologically important areas. For example, the mammal group did not have mapping data on the habitat of the grey whale, the bird group lacked mapping data for any species in the Democratic People's Republic of Korea and the fish group did not have mapping data for the roughskin sculpin (*Trachidermus fasciatus*), which was given a status of endangered species in Japan.

General knowledge gaps
Effects of human disturbances were identified as a general knowledge gap by some groups (mammal, bird, and fish groups). There is a lack of data on the effect of bycatch and boat collisions on mammals; the effect of large-scale reclamation on bird groups, and the influence of human activities on the fish groups.

Other types of knowledge gaps were the influence of climate change (fish group), ecosystem services provided by coastal plants to the coastal ecosystem (coastal plants).

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