IMPLEMENTING THE STRATEGIC ACTION PROGRAMME FOR THE YELLOW SEA LARGE MARINE ECOSYSTEM: RESTORING ECOSYSTEM GOODS AND SERVICES AND CONSOLIDATION OF A LONG-TERM REGIONAL ENVIRONMENTAL GOVERNANCE FRAMEWORK

(UNDP/GEF YSLME Phase II Project)

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4th Meeting of the Interim Commission Council (ICC-4) of the UNDP/GEF YSLME Phase II Project

Jeju, RO Korea
28-29 November 2019

Update of the YSLME Transboundary Diagnostic Analysis (TDA)

1. This cover note was prepared by the Secretariat.

<u>Introduction</u>

2. At the 2nd Meetings of the MSTP and ICC (March 27-29, 2018; Dalian), PR China and RO Korea agreed to conduct NSAP reviews in line with agreed guidelines for consolidation into the updated TDA by an international consultant.

3. At the 3rd Meetings of the MSTP and ICC (March 12-14, 2019; Qingdao), the partners agreed upon the process and timeframe to update and adopt the TDA and SAP of the YSLME and requested the Secretariat and the international consultant to update the TDA and SAP with participation of relevant stakeholders. On the basis of the NSAP review reports prepared by PR China and RO Korea, the international consultant consolidated into the updated TDA in July 2019, which were subsequently reviewed and commented for revision by the International Consultant.

4. At the 3rd YSLME Science Conference, four parallel sessions were organized on biodiversity, fisheries sciences, microplastics and marine litter and nutrients to contribute to the understanding of the state of the Yellow Sea in support of the TDA update.

5. Consequently, the international consultant prepared the 2nd version of the updated TDA taking into consideration of comments from the two review meetings of the updated TDA organized

by the two countries for review at the ICC-4. The 2nd version of the updated TDA is attached as an Annex to this document.

6. On November 27, a consultation meeting on the update of the TDA will be organized to review and validate the problems, cause-chain analysis, socioeconomic impacts, legal and institutional framework, and conclusions and recommendations. The meeting will adopt the consensus reached at the meeting by the members of the six Regional Working Groups (RWGs), which will be ready immediately after the close of the consultation meeting on November 27, 2019, and discuss the timeframe for adoption of the TDA.

Recommendation

7. The Secretariat recommends that:
   a. the 4th Meeting of the ICC:
      i. Endorse the consensus being reached at the consultation meeting on the 2nd draft of the updated TDA;
      ii. Encourage the Secretariat to facilitate the active participation of the stakeholders in review and validating the conclusions and recommendations of the updated TDA; and
      iii. Request the international consultant to prepare 3rd version of the updated TDA to be distributed by the Secretariat for review and subsequent approval via communication by the partners.

Transboundary Diagnostic Analysis for the Yellow Sea Large Marine Ecosystem

2019 Update, November 2019 Draft

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Abbreviations

[Abbreviation]	[Spell out]
CPUE	Catch per unit effort
DPRK	Democratic People's Republic of Korea
GEF	Global Environment Facility
IMTA	Integrated multi-trophic aquaculture
LME	Large Marine Ecosystem
MARPOL	International Convention for the Prevention of Pollution from Ships
MSY	Maximum Sustainable Yield
TAC	Total allowable catch
[Abbreviation]	[Spell out]
[Abbreviation]	[Spell out]

Executive Summary

This project builds upon regional cooperation for the sustainable use of the Yellow Sea Large Marine Ecosystem (YSLME) put in place by China and the Republic of Korea, supported by the Democratic People's Republic of Korea, the Yellow Sea Partnership and the Global Environmental Facility (GEF) with an objective to foster a long-term sustainable institutional, policy, and financial arrangements for effective ecosystem-based management for the Yellow Sea (YS). To achieve this objective, the YSLME prepared a regional Transboundary Diagnostic Analysis (TDA) and a regional Strategic Action Programme (SAP), the implementation of which was operationalized by the national SAP.

According to the TDA (2007) developed at the Phase I of the Project as well as to the new information reported since then, nine major transboundary environmental concerns have been identified: 1) Pollution and contaminants; 2) Eutrophication; 3) Harmful Algal Blooms (HABs); 4) Fishing effort exceeding ecosystem carrying capacity; 5) mariculture facing unsustainable problems; 6) Habitat loss and degradation; 7) Change in ecosystem structure; 8) Jellyfish blooms; and 9) Climate change-related issues. However, the YS ecosystem and its ecosystem carrying capacity (ECC) has been changed since 2007 due to all pressures exerted on the ecosystem in the YS.

Acknowledging significance of both TDA and SAP by both China and Korea during the 1st and 2nd Interim Commission Council (ICC) Meeting, an issue on updating both the TDA and SAP was raised and agreed to proceed for updating TDA and SAP by addressing all nine concerns based on scientific findings and assessment with an aid of an consultant and working group members. The analysis in the TDA was involved in an identification of the causes and impacts of environmental disturbances and/or threats and assess the scale and distribution of impacts at national and regional levels. The causal chain analysis (CCA) was applied for identification of the major causes and its impacts driving into environmental degradation in the Yellow Sea.

Technically in this report, the needs of concept of Ecosystem Carrying Capacity (ECC) especially on fish stock conservation in the Yellow Sea were suggested by harmonizing scientific basis for the management of fish stocks both in PR China and RO Korea. Also, to reduce the entry of submerged and floating wastes including microplastics into marine environment where it interferes with both recreational and fishing activities, it was suggested to consider of having strong commitment from municipal sectors along with advanced monitoring system. Also, as a polyculture application to mariculture, Integrated Multitrophic Mariculture Aquaculture (IMTA) was introduced as an innovate technique in which pelagic fish, molluscs and seaweeds could be grown in sequence along the prevailing current direction in coastal areas. This practice with innovative and environmental-friendly concept is worth of considering wider application as a means of minimizing the adverse effects and maximizing the benefits of mariculture. It is recommended that this approach would provide a vehicle for harmonizing the marine natural resource management frameworks between two countries for the conservation of the Yellow Sea.

In conclusion, with all findings addressed, this report provides the basis for the formulation of a SAP embodying specific actions, or interventions, that can be adopted multilaterally to restore, or preserve from further degradation in the Yellow Sea.

1 INTRODUCTION

The Yellow Sea Large Marine Ecosystem (YSLME) Phase II Project builds on a decade of regional cooperation between China and Korea in the management of the Yellow Sea ecosystem and the services it provides. This transboundary cooperation was achieved using an approach developed by the Global Environment Facility to coordinate the interrelated science and policy activities necessary for effective ecosystem management. This approach involves first developing a comprehensive assessment of the scientific knowledge of the ecosystem, and includes an evaluation of the primary problems and threats to the ecosystem. This information is presented as the Transboundary Diagnostic Analysis (TDA) and reflects the joint efforts of the nations involved. The TDA thus provides an agreed-upon set of information on which to develop management strategies.

The second part of the GEF approach is to take the results of the TDA and develop a set of ecosystem quality objectives for the sustainable management of the ecosystem. These objectives are realized through the further development of management actions with measurable outcomes. These efforts result in a Strategic Action Programme (SAP). The SAP is a politically negotiated document that provides a blueprint for attaining a sustainable ecosystem.

The original TDA and SAP for the YSLME was developed during the YSLME Phase I Project (2005-2009). The current YSLME Phase II project (2014-2020) implements the Phase I SAP. During this concluding year of the Phase II project, one of the final activities is to update the TDA and SAP documents. These updates reflect the current state of knowledge of the ecosystem, and a revised set of priorities for sustainable management of the YSLME.

1.1 Project History

1.1.1 YSLME Phase I: TDA and SAP Development

The UNDP / GEF project, "Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem", was commissioned by the UNDP as Implementing Agency and UNOPS as the Executing Agency. The project was initiated in 2005 and concluded in 2010. The original four objectives of the project were:

1. Develop regional strategies for sustainable management of fisheries and mariculture;
2. Propose and implement effective regional initiatives of biodiversity protection;
3. Propose and implement actions to reduce stress to the ecosystem, improve water quality, and protect human health; and
4. Develop and pilot regional institutional capacity building initiatives.

An innovative feature of the project was a focus on ecosystem-based management based on the concept of ecological carrying capacity (ECC). The project strategy involved work in three fundamental areas: assessment, planning for stress reduction, and demonstration projects. Assessment activities consisted of collating and reviewing information about the ecosystem, and targeted efforts to fill in gaps by gathering new information, and by assessing this information to identify the causes of problems and options for remedial actions. The Transboundary Diagnostic Analysis (TDA) was a key component of this phase. To the extent possible in the Phase I project, management actions defined in the SAP process were implemented through demonstration projects.

The key outcomes of the Phase I project included both planning documents and the development of institutional frameworks that would carry forward to the Phase II project and beyond. The regional TDA document was produced in

2007 (UNDP/GEF 2007). This document defined the primary environmental problems in the ecosystem and analysed those problems in terms of the immediate, underlying, and root causes for the problems. This causal chain analysis laid the groundwork for developing remedial actions to address the problems in the SAP.

The SAP document was produced in 2009 and proposed a set of regional management actions to address the environmental problems identified in the TDA. The SAP was structured along an ecosystem services model, whereby management actions were framed in terms of Provisioning Services (fisheries), Regulating Services (nutrients and ocean pollutants), Cultural Services (marine litter and beach contamination), and Supporting Services (protection of ecosystems, habitats, and biodiversity). Within these service areas, 11 targets were developed, to be implemented through 32 management actions (Table 1).

Table 1. Targets and Management Actions from the 2007 SAP.

Provisioning Services

Target 1: 25-30% reduction in fishing effort

Action 1-1: Control fishing boat numbers
Action 1-2: Stop fishing in certain areas/seasons
Action 1-3: Monitor and assess stock fluctuations

Target 2: Rebuilding of over-exploited marine living resource

Action 2-1: Increase mesh size
Action 2-2: Enhance stocks
Action 2-3: Improve fisheries management

Target 3: Improvement of mariculture techniques to reduce environmental stress

Action 3-1: Develop environment-friendly mariculture methods and technology
Action 3-2: Reduce nutrient discharge
Action 3-3: Control diseases effectively

Regulating Services

Target 4: Meeting international requirements on contaminants

Action 4-1: Conduct intensive monitoring and assessment
Action 4-2: Control contaminants discharge with reference to Codex alimentarius and Stockholm Convention
Action 4-3: Implementing MARPOL 1973/78 effectively

Target 5: Reduction of total loading of nutrients from 2006 levels

Action 5-1: Control total loading from point sources
Action 5-2: Control total loading from non-point sources and sea-based sources
Action 5-3: Apply new approaches for nutrient treatment

Cultural Services

Target 6: Reduced standing stock of marine litter from current level

Action 6-1: Control source of litters and solid wastes
Action 6-2: Improve removal of marine litter
Action 6-3: Increase public awareness of marine litter

Target 7: Reduce contaminants, particularly in bathing beaches and other marine recreational waters, to nationally acceptable levels

Action 7-1: Conduct regular monitoring, assessment and information dissemination particularly in bathing beaches and other recreational waters
Action 7-2: Control pollution in bathing beaches and other marine recreational waters

Supporting Services

Target 8: Better understanding and prediction of ecosystem changes for adaptive management

Action 8-1: Assess and monitor the impacts of N/P/Si ratio change
Action 8-2: Assess and monitor the impacts of climate change
Action 8-3: Forecast ecosystem changes in the long-term scale
Action 8-4: Monitor the transboundary impact of jellyfish blooms
Action 8-5: Monitor HAB occurrences

Target 9: Maintenance and improvement of current populations/distributions and genetic diversity of the living organisms including endangered and endemic species

Action 9-1: Establish and implement regional conservation plan to preserve biodiversity

Target 10: Maintenance of habitats according to standards and regulations of 2007

Action 10-1: Develop regional guidelines for coastal habitat management
Action 10-2: Establish network of MPAs
Action 10-3: Control new coastal reclamation
Action 10-4: Promote public awareness of the benefits of biodiversity conservation

Target 11: Reduction of the risk of introduced species

Action 11-1: Control and monitor ballast water discharge
Action 11-2: Introduce precautionary approach and strict control of introduction of non-native species

In addition to the TDA and SAP documents, an important outcome of the Phase I project was the development of institutional frameworks that could be carried forward to future projects. The ultimate goal of sustained ecosystem management in the Yellow Sea was the development of a YSLME Commission. The objectives of the commission were better coordination of national ecosystem management efforts and more effective regional management efforts, within the context of a non-legally binding and cooperation-based institution. To support these efforts. An Interim Commission Council (ICC) was developed.

Other institutional bodies were also created to manage technical and governance aspects of ecosystem management in the YSLME. Regional Working Groups (RWGs) with related National Working Groups (NWGs) were established within the disciplinary areas of fisheries, mariculture, habitat, pollution, monitoring and assessment, and governance. A management, Science, and Technical Panel (MSTP) was developed to provide guidance to the RWGs.

The Phase I project was concluded in 2010, with the expectation that a second phase project would be launched to implement the SAP and continue work toward establishing the YSLME Commission.

1.1.2 YSLME Phase II: SAP Implementation

The YSLME Phase II project, "Implementation of the Yellow Sea LME Strategic Action Programme for Adaptive Ecosystem-Based Management", was launched in 2014 to implement the Phase I SAP. This project is currently underway and has a mid-2020 date for completion of technical activities and a December 2020 full completion date. As with the Phase I project, UNDP is the Implementing Agency and UNOPS is the Executing Agency. The project objective is

> *Restore the ecosystem goods and services of the Yellow Sea and secure the establishment of an effective long-term regional environmental governance mechanism through the YSLME Commission[1].*

Project design is consistent with the ECC approach defined in the 2009 SAP and is designed for implementation through four components, three of which are associated with the four ecosystem services of provision, regulation, cultural, and supporting services (Table 2).

Table 2. Components and Outcomes of the YSLME Phase II Project.

Component	Outcome	
Component 1. Ensuring sustainable regional and national cooperation for ecosystem based management, based on strengthened institutional structures and improved knowledge for decision making.	1.1	Regional governance structure, the YSLME Commission established and functional, based on strengthened partnerships & regional co-ordination; wider stakeholder participation and enhanced public awareness.
	1.2	Improved inter-sectoral coordination and collaboration at the national level, based on more effective Inter-Ministry Coordinating Committees.
	1.3	Wider participation in SAP implementation fostered through capacity building and public awareness, based on strengthened Yellow Sea Partnership and wider stakeholder participation; improved environmental awareness; enhanced capacity to implement ecosystem-based management.
	1.4	Improved compliance with regional and international treaties, agreements, and guidelines.
	1.5	Sustainable financing for regional collaboration on ecosystem-based management secured, based on cost-efficient and ecologically effective actions.
Component 2.	2.1	Recovery of depleted fish stocks as shown by increasing mean trophic level.
	2.2	Enhanced fish stocks through re-stocking and habitat improvement.

Improving Ecosystem Carrying Capacity with Respect to Provisioning Services	2.3	Enhanced and sustainable mariculture production, by increasing production per unit area as means to ease pressure on capture fisheries.
Component 3. Improving Ecosystem Carrying Regulating and Cultural Services	3.1	Ecosystem health improved through a reduction in pollutant discharge (e.g. nutrients) from land-based sources.
	3.2	Wider application of pollution- reduction techniques piloted at demonstration sites.
	3.3	Strengthened legal and regulatory processes to control pollution.
	3.4	Marine litter controlled at selected locations.
Component 4. Improving Ecosystem Carrying Capacity with Respect to Supporting Services	4.1	Maintenance of current habitats and the monitoring and mitigation of the impacts of reclamation.
	4.2	MPA Network strengthened in the Yellow Sea.
	4.3	Adaptive Management mainstreamed to enhance the resilience of the YSLME and reduce the vulnerability of coastal communities to climate change impacts on ecosystem processes and other threats identified in the TDA and SAP.
	4.4	Application of ecosystem-based community management (EBCM) preparing risk management plans to address climate variability and coastal disasters.

To implement the SAP, China and Korea each developed National Strategic Action Programmes (NSAPs) which were designed to be consistent with both the regional SAP developed in the Phase I project and national priorities identified by relevant ministries and stakeholders. The institutional bodies developed in the Phase I project were continued in the Phase II project and consist of:

- Management, Science, and Technical Panel (MSTP)
- Regional Working Groups (RWGs)
- Inter-Ministry Coordinating Committee (IMCC)
- National Coordinator (NC)
- National Working Groups (NWGs)
- Commission Secretariat

Activities to implement the SAP have been diverse and comprehensive, but can be categorized generally as:

- Legal, institutional, and governance reform & regional governance mechanisms
- Demonstration projects & scientific studies
- Technical capacity building and training
- Public awareness and education programmes
- Regional Monitoring and data management networks
- Expansion of marine protected areas

Among the activities during the final year of the Phase II project are updates for the TDA and SAP documents. These updates are intended to capture the progress made in understanding the ecosystem, perspectives on the management of the ecosystem, and governance changes that have occurred since the original TDA and SAP documents were produced. This document (TDA Update 2019) focuses on new knowledge obtained since the original TDA document in 2007. Much of this information was collected as a direct result of SAP implementation. The SAP Update document to follow (SAP Update 2019) provides an analysis of the impact and relevance of the targets and management actions undertaken in the YSLME Phase II project. The key output of the SAP update is a revised set of targets and management actions intended to guide policy development in the next steps in the management of the YSLME.

1.2 Methodology

1.2.1 Scope

The 2007 TDA laid the groundwork for SAP development and implementation through a thorough process of identifying priority problems, defining working groups to address the problems, and undertaking a causal chain analysis to determine immediate, underlying, and root causes for the problems. TDA documents commonly also include national and regional reports on legal and institutional frameworks and stakeholder, governance, and socioeconomic analyses. To some extent these components were addressed in the 2009 SAP and in YSLME Phase II activities. This TDA Update will summarize activities undertaken in these areas and make recommendations for further action in the next project phase.

1.2.2 Information Sources

The primary information sources for this TDA update are progress reports prepared in 2018 by China and Korea on implementation of each country's National Strategic Action Programmes: These are, "Interim Review Report on the Progress of Implementation of the National Strategic Action Programme for YSLME 2009-2020 of the People's Republic of China" (September 2018) and "An Analytical Study on the Implementation of the National Strategic Action Plan (NSAP) for the Yellow Sea Large Marine Ecosystem (YSLME) of the Republic of Korea (June 2019). Other data sources were used as needed and available. These are cited in the text and listed in Section 7 References.

1.2.3 Approach

Using GEF methodologies, the Transboundary Diagnostic Analysis (TDA) provides the mutually agreed factual basis for the policy instruments that are proposed in the Strategic Action Programme document. The structures of TDAs vary across projects. The 2007 YSLME TDA had several key features:

- Background information on the TDA/SAP process
- Geographic and disciplinary scope for the YSLME project
- A summary of scientific data relevant to the ecosystem and its problems
- A causal chain analysis and description of root causes
- Chapters describing transboundary versus domestic problems, options for interventions, considerations for SAP preparation, and conclusions.

These features were preserved in this TDA update. The update process included the following information gathering, validation, and revision steps:

1. Development of a draft TDA update document. This document was submitted for review by the Secretariat, the RWGs, and other relevant stakeholders.
2. Update of the Causal Chain Analysis and Priority Transboundary Problems. A workshop on the TDA and SAP updates was conducted at the 3rd YSLME Science Conference in Qingdao on July 17-18, 2019. This included an examination of the causal chain for priority problems in the YSLME and an assessment of emerging problems.
3. National meetings to review the TDA. Separate national meetings were held in August 2019 in Seoul, ROK and Wuhan, PRC. Comments from RWGs, NWGs, and other stakeholders were provided regarding the TDA in general and the causal chain analysis in particular.
4. TDA validation. Revisions to the TDA were discussed and finalized at the 4th Interim Commission Council (ICC) meeting in Jeju, ROK in November 2019.

The finalized TDA Update document is not comprehensive in terms of the state of knowledge of the YSLME, but does reflect the current understanding of priority problems in the system and their causes. As such, it can be used as a planning instrument for future interventions.

1.3 The Geography of the Yellow Sea

The Yellow Sea is defined by the Chinese mainland to the west and the Korean Peninsula to the east (**Figure 1**,). The Bohai Sea to the north drains into the Yellow Sea and to the south, the Yellow Sea connects to the East China Sea. For the purposes of defining boundaries, the northwestern project extent is a line drawn in a northeasterly direction from Penglai on the Shandong Peninsula, to Dalian. The Bohai Sea is excluded from the project area. The southern boundary is defined by a line drawn from the north bank of the Yangtse River (Chang Jiang) estuary to the south side of Jeju island and from there north to the Korean mainland (TDA p 15 – 16).

Figure 1. From http://www.yslmep.org/?page_id=43.

The project area covers about 400,000 km^2 and measures about 1,000 km along the north-south axis and about 700 km maximum width. The floor of the Yellow Sea is post-glacially submerged portion of the continental shelf, characterized by shallow depths (44 m average depth and 100 m maximum depth), and a gently sloping seafloor within the project area. The major rivers flowing into the Yellow Sea are the Yellow, Han, Yangtse, Datung, Yalu, Guang, and Sheyang Rivers. These rivers deliver more than 1.6 billion tons of sediment to the Yellow Sea annually, with the Yellow Sea providing most of the sediment load (TDA, p 15).

The open connections with the Bohai Sea to the north and the East China Sea to the south form a continuous circulation pattern, which varies seasonally. Water circulation in the Yellow Sea is primarily driven by winter cooling and summer heating, freshwater discharge from rivers, and perhaps the inflow of warm saline waters in a branch of the Kuroshio [Define this]. Wind forcing and freshwater runoff are also influenced by the cold and dry northerly winter monsoon and the warm, humid southerly summer monsoon. The major water masses of the Yellow Sea are the Yellow Sea Cold Water, the Yellow Sea Warm Current Water and Yangtze River mixed water. The Yellow Sea Cold Water is formed during winter cooling and occupies the lower layer of the basin. This water mass survives throughout the summer. The Yellow Sea Warm Current Water is relatively saline and flows northwestward between Sokotra Rock and Jeju Island, into the Jeju Strait and the eastern Yellow Sea. The predominant direction of outflow from the Yangtze is to the south, consistent with geostrophy, but, in the summer, Yangtze River mixed water extends northeastward toward Jeju Island and lowers the salinity of waters west of Jeju Island (TDA p 17).

Current speeds in the eastern part of the Yellow Sea are usually less than 0.2 knots except for areas near Huksando and Jeju Islands, where stronger currents are observed. In summer, the circulation of the Yellow Sea is characterized by southward flowing Chinese coastal water, northward flowing Yellow Sea Warm Current, influenced by the Kuroshio to the east, and the northeastward movement of water from the East China Sea, with a central cyclonic gyre (Su, 1998). In winter, the central cyclonic gyre is not as pronounced, but apart from the southward coastal flow along the Korean Peninsula, the overall circulation of the Yellow Sea remains essentially cyclonic (**Figure 2**, *Figure 1, SAP, p 2* (TDA, p 17)

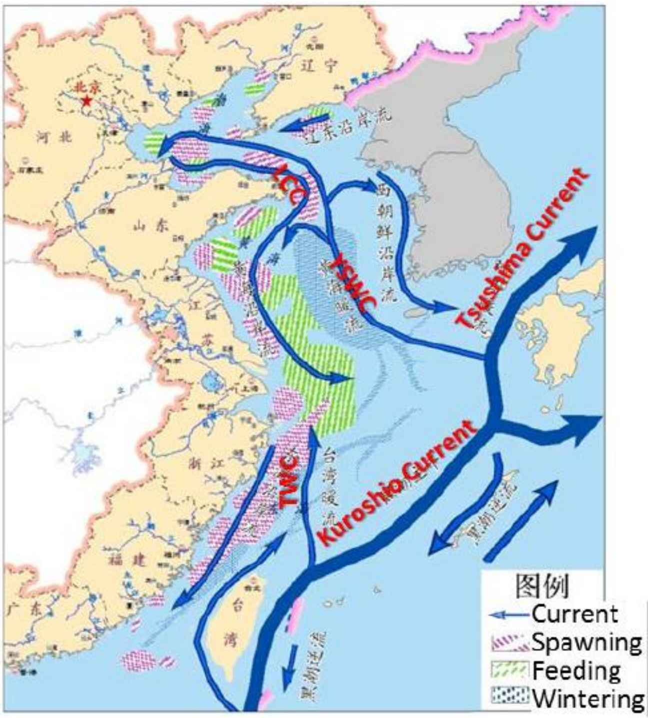


Figure 2. Circulation currents in the YSLME, and zones associated with fishery life cycles. (Reproduced from Zhang, 3rd Science Conference Keynote Presentation).

The surface sediments of the Yellow Sea are mostly terrigenous, carried by rivers and winds from the surrounding lands. The annual input of fine-grained detritus to the Bohai Sea was, until recently, about one billion tonnes per year. Over 90% of this sediment load has been delivered historically by the Yellow River, but this has already decreased and projections made in 2006 estimated that by 2019 *(need to find more recent data*) sediment loads from the Yellow River would decrease to about 300 million tonnes per year as a result of engineering works on the Yellow River. Excluding the Yangtse River, about 50 million tonnes of sediment are discharged by rivers directly into the Yellow Sea proper, including a considerable amount of coarse-grained material from rivers draining the Korean Peninsula. Unconsolidated surface are distributed by tidal currents, longshore currents, waves, and the Yellow Sea Warm Current. Fine sediment is deposited where current and wave actions are the lowest. As a result, fine-grained surficial sediments are found in the central region of the yellow Sea, on the Chinese coast, and on the southwest and southern coasts of Korea. Sandy sedimentary facies exist in the eastern central portion of the Yellow Sea and central and northern coastal areas of the Korean Peninsula. (TDA p 17).

2 YELLOW SEA ECOSYSTEMS

2.1 Fisheries

The Regional Working Group on Fisheries (RWG-F) identified two priority problems related to fisheries: Declines in landings in commercial fisheries, and unsustainable maricultural practices (TDA 2007).

2.1.1 Capture Fisheries

A significant growth in commercial fisheries in the Yellow Sea over the past several decades has been a positive socioeconomic force, but has resulted in overexploitation of the fishery and changes to the species composition of fisheries. Management actions have been oriented toward reducing the level of fishing efforts and rebuilding marine living resources (Table 3).

| Table 3. Management Actions Related to Commercial Fisheries

Action 1.1	Reduce the number of fishing vessels and maintain a proper mid/long term level of fishing efforts in consideration of the fish stock.
Action 1.2	Designate the closed areas and seasons for protection of spawning and recruitment stock resources.
Action 1.3	Monitor and assess fish stocks.
Action 2.1	Increase Mesh Size
Action 2.2	Enhance Fish Stocks
Action 2.3	Improve Fishery Management

Over the past several decades, the combined coastal areas of China and Korea have supported a significant proportion of global fish production. This contribution has increased steadily from about 9% in 1986 to almost 20% in 2004 (TDA 2007). The species being captured have shifted over the years, with cycles of abundance stimulating increased fishing intensity. As catch intensity overtakes recruitment, declines in the catch of one species results in increased fishing effort for another. In the decades since the late 1950s the fisheries of the YSLME underwent two fundamental transitions. From the late 1950s to the late 1990s, the fisheries shifted from demersal, high-valued species to pelagic low-valued species. Then from the late 1990s to 2014 – 2015, the fisheries shifted from pelagic low-valued to demersal low-valued species (C-NSAP, p 10).

Two mechanisms are likely responsible for these shifts in species dominance, with implications for both stock decline and recovery. The first is knows as *systematic replacement*. This occurs when a dominant species declines in abundance, either naturally or through overfishing. Another competitive species takes advantage of the surplus food and vacant space to increase its abundance. The second mechanism is ecological replacement. This occurs when environmental changes gradually restructure the ecosystem, resulting in changes in stock abundance. In the long term, these two drivers may be intermingled (Tang 1993, 2004). Once fisheries restoration measures have been implemented, stock recovery may be slow due to both of these ecological phenomena (C-NSAP, p 10).

A combination of management actions implemented since the 2007 TDA has improved fisheries in the Yellow Sea. Fishing pressure was relieved on fisheries through vessel buy-back programs (Action 1.1), seasonal closure of commercial fisheries (Action 1.2), and regulations on fishing practices, including specifications on allowable mesh sizes for nets (Action 2.1).

The vessel buy-back program (Action 1.1) has been an ambitious and effective mechanism to relieve pressure on fisheries. In China, measures to reduce fishing boat numbers predate the 2008 SAP. In 2003 a control system for the period 2003 – 2010 was implemented. During that period 30,000 fishing vessels were decommissioned through a governmental buy-back program. This program was renewed for the period 2010 – 2020 and is anticipated to meet the target of 20, 000 additional vessels removed from service. Between 2015 and 2020, the provinces along the Yellow Sea will decommission 4,633 large and medium sized vessels, representing a 23% reduction in numbers. In terms of power, this is a reduction in 741,031 kW, or 54.9% (China NSAP, Table 2.1). In Korea, the number of fishing vessels was reduced from 26,439 in 2011, to 21,929, in 2017, for a 17% reduction. However, Korea has been reducing the number of fishing vessels by six to eight percent each year prior to 2011. Thus the annual amount of reduction has decreased somewhat since 2011.

Restrictions on locations and seasons for commercial fishing (Action 12) ban showed immediate success across a wide range of species. Since 2017, there has been a comprehensive fishing ban for 4 months north of 35° N and 4.5 months south of 35° N. In response, average fish biomass increased compared with the pre-implementation year of 2015. the average biomass indicator of pelagic species (e.g., Japanese anchovy, chub mackerel, silver pomfret, and half-fin anchovy) increased more than 94%, the average biomass indicator of demersal fish (e.g., yellow croaker, Pacific cod, and angler fish) increased by 46 to 127 %. Average body length of individuals increased. Recruitment stock biomass increased and population structure went from simple to complex (C-NSAP, p 5). Closed areas in Korea are based on Fisheries Resources Management Act and Article 7(1) of the Enforcement Decree within that act. See the Korea NSAP, Table 5 for detailed information.

The long-term CPUE changes of fishery resources in the YS are well described in the Figure 3, showing high values in the 1958-1959 compared to the ones after that period which could be ascribed into the overfishing (Tang 1989 and 1993). Overall biomass of fishery respires in the YSLME showed relatively stable pattern in last 30 years.

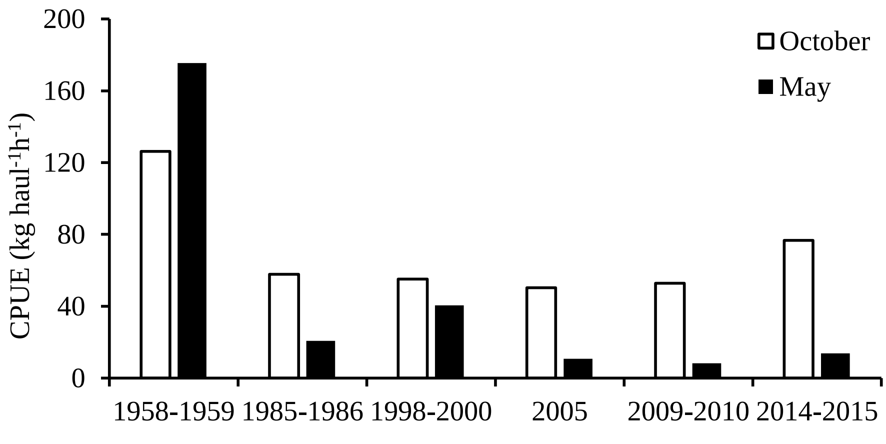


Figure 3. Long-term CPUE changes of fishery resources in the YS

Based on the number of fishing vessels in RO Korea, CPUE showed a pattern of increasing steadily from 5.45 metric tons in 2004 to 7.42 metric tons in 2010. However, it plummeted to 6.06 metric tons in the following year and fluctuated with a value of 5.66 metric tons recorded in 2016. Considering the tonnage (MT) of fishing vessel, CPUE showed a pattern of continuous increasing for 5 years from 1.55 metric tons in 2004 to 2.22 tons in 2009. After showing a pattern of continuous decline, it hit 1.39 tons in 2016. It is noticeable that this figure is lower than 1.55 tons of 2004 as well as the record low of CPUE over the entire analysis period (Figure 4).

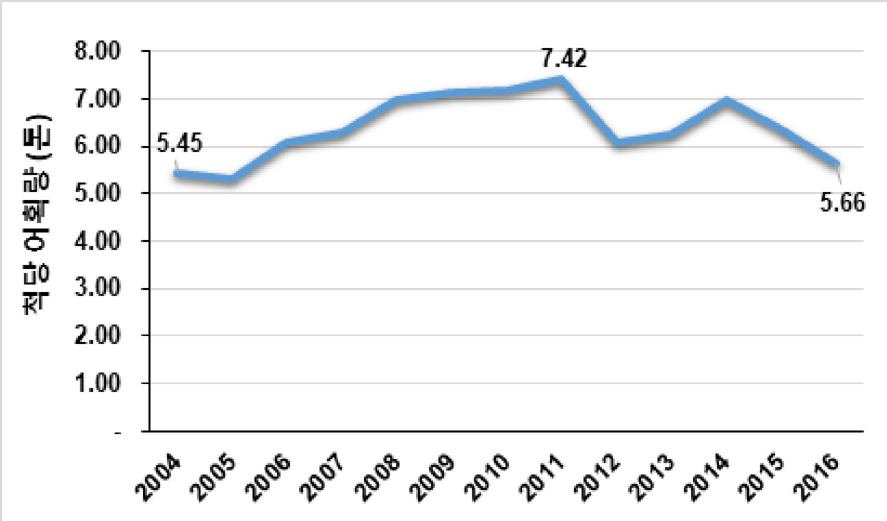


Figure 4. Patterns of CPUE in the YS

Efforts to enhance fish stocks (Action 2.2) include re-stocking programs and the development of artificial reefs, marine forests, and marine ranching. China has undertaken a restocking program for more than 100 species, including freshwater species and endangered species (C-NSAP, p13). The China NSAP reports that extensive studies on the effects of stock enhancement have been conducted, including consideration of the genetic and ecological risks. A series of innovative studies was used to guide the conservation of fishery resources. Since 2018, China –Korea joint stock enhancement program has been conducted every year, with longer term cooperation anticipated (C-NSAP, p13).

According to the summary report on "Implementation of the fishing vessel buyback program in the Yellow Sea of Korea and its effectiveness analysis" authored by Dohoon KIM of RO Korea in 2019, catches of the coastal and offshore fisheries in the Yellow Sea of Korea has been shown with a pattern of constant declining over the past 40 years. After marking a record high of 646,000 metric tons in 1986, the catch amount has been decreased gradually until 2017 (see Figure 5). It is noticeable that the catch in 2017 was equivalent to 58% of that in 1986 and also was decreased by 2% per year on average between 1986 and 2017. It was found that the proportion of the fishery production in the coastal and offshore waters has been decreasing. The catch in the Yellow Sea, which had accounted for 40% of the country's total coastal and offshore fishery production in 1986, fell to 23% of the total in 2015. The decreasing proportion of the Yellow Sea catches in the country's total catches which are also on the decline indicates a faster reduction in the catch in the coastal and offshore waters of the YS than the catch observed in the overall coastal and offshore waters of the country.

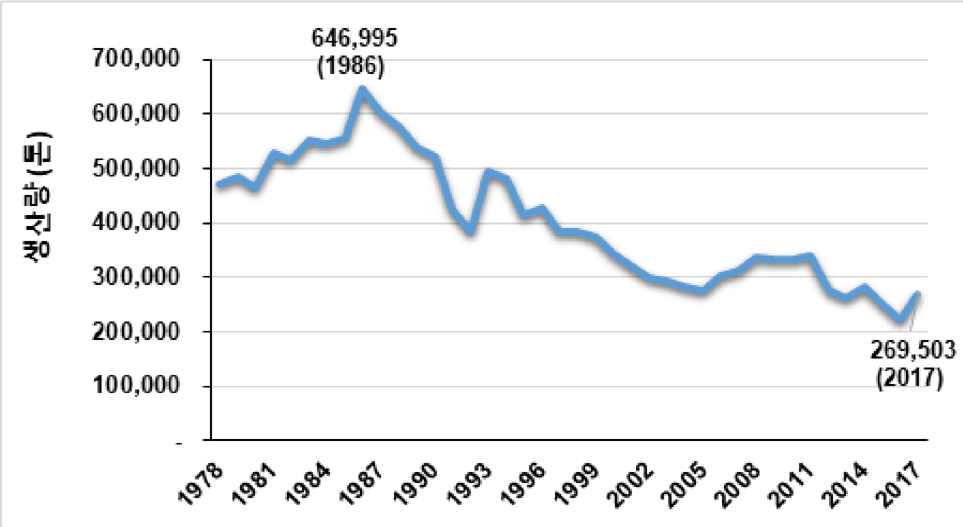


Figure 5. Patterns of catches of the coastal and offshore fisheries in the YS of RO Korea

In Korea, from 2011 to 2016, 2.9 ha of artificial reefs have been installed. With regard to marine forests, the goal in Korea was to create over 54,000 ha of marine forests from 2009 to 2030. As of 2017, 15,242 hectares of marine forest have been created. Also, Korea has planned to establish 50 coastal marine ranches from 2006 to 2022. As of 2017 45 have been created (K-NSAP p 27 – 30).

Improvement in fisheries management (Action 2.3) includes the activities described above, with additional activities. China has implemented a series of control strategies oriented toward limiting access to fish harvesting. These include closing areas and seasons to fishing; establishing fishery genetic resource protection areas; requiring fishing licenses; setting limits on catchable fish sizes and the proportion of juvenile fish; requiring a sea area user fee for stock protection and enhancement activities; and implementation of the fishing vessel buy-back program and reductions in fuel subsidies (C-NSAP, p13 – 15).

Fisheries management activities In Korea include managing use of fishing gear, limiting the use of fishing gear, and voluntary management of fishing. Since 2011 the TAC exhaustion rate has gradually decreased, meaning that fishery catches have not been exceeding the allowable catch. In 2011, the exhaustion rate was over 80%, but that figure fell to about 46% by 2017. These measures have a regulatory basis in the revision of the Fisheries Act (1995), revision of the Fishery Resources Protection Decree (1996), and the enactment of the Regulations on the Management of the Total Allowable Catch (1998) (K-NSAP, p 30 – 34).

2.1.2 Mariculture

The YSLME Phase I Regional Working Group on Fisheries (RWG-F) identified as a priority the rapid expansion of mariculture without adequate understanding of the consequences. Over the period from 1995 to 2015, Yellow Sea maricultural production increased from 400,000 tonnes per year to about almost 900,000 tonnes per year. Concerns related to mariculture are based on the high density of organisms and include the sedimentation of organic matter, transmission of diseases, and nutrient releases.

Traditional maricultural practices involved growing monocultures of finfish, crustaceans, molluscs, or seaweed in marine enclosures open to circulation from coastal waters. These waters provide nutrients to grow the organisms and flush away waste products. Land-based aquaculture systems operate on the same principle, recirculating nearby seawater to serve the same purposes of nutrition and waste removal.

It is known that mariculture also leads to negative impacts on environmental quality. During the breeding process, emission of N, P and COD to the marine environment, beyond the nearshore marine environmental capacity and self-purification ability, as a result of eutrophication and the marine ecological environment destruction. In addition, mariculture may produce large amounts of self-pollutants, including particulate matter (residual feed and faeces) and dissolved metabolic wastes (ammonia and phosphorus).

Management actions related to mariculture (Table 4) were designed to reduce the risks and environmental impacts associated with mariculture through three strategies: implementing a more advanced system for marine systems (Action 3.1), improving the technology of land-based systems (Action 3.2), and developing detection and response strategies to control diseases (Action 3.2).

| Table 4. Management Actions Related to Mariculture.

Action 3.1	Reduce water-borne pollution and enhance the health of farmed organisms through Integrated Multi-Trophic Aquaculture (IMTA)
Action 3.2	Improve the technology for seawater recirculating aquaculture systems (RAS).
Action 3.3	Implement early warning and diagnosis systems for effective management of diseases.

A relatively new approach in mariculture is Integrated Multi-trophic Aquaculture (IMTA). Rather than to farm one marine species, IMTA systems mimic ecosystems by including organisms that occupy a range of trophic levels. The organic or inorganic substances such as feed, faeces, and nutrients produced by feeding units (such as fish and shrimp), become the feed for other types of cultured units (e.g., filter feeders and sediment feeders) in the system. An IMTA system using seaweed and shellfish demonstrated the feasibility of this concept. Through photosynthesis and metabolic processes, kelp were net producers of oxygen, while removing carbon, nitrogen, and phosphorus. This nitrogen uptake offsets the nitrogen excretion of the shellfish. If fish are introduced into the system, the shellfish could consume significant quantities of particles excreted by the fish (C-NSAP, p 4 – 5).

IMTA systems have been implemented in Korea in small-scale projects conducted by the National Institute of Fisheries Science (NIFS) from 2011 to 2018. Through at least three demonstration projects, IMTA facilities and techniques were demonstrated and proven at the pilot scale, but have not yet been launched at commercial scales (K-NSAP, p 37).

Land-based aquaculture systems are essentially point-sources of nutrient loading to coastal areas and can be pathogen sources as well. Activities related to Action 3.2 were focused on minimizing the impact of aquaculture facilities by treating and recycling water and introducing environmentally friendly feed sources (C-NSAP, p 4). Research and development projects in Korea focused on alternative feeds using alternative feed sources and developing bio-filtration systems to improve water quality. These projects, like those related to IMTA, develop technology that can make commercial-scale facilities possible (K-NSAP, p 39 – 40).

2.2 Pollutants

In the Phase I, YSLME project, the Regional Working Group on Pollution (RWG-P) identified nitrogen and phosphorus, fecal substances, heavy metals and organic contaminants, and marine litter as the major pollution problems in the Yellow Sea (C-NSAP, p 18). The Phase II YSLME SAP Implementation project addressed these pollutants in ten management actions, which fall into the general categories of water and sediment quality, marine litter, and contaminants.

2.2.1 Water and Sediment Quality

Water and sediment quality have been addressed in SAP Implementation in terms of monitoring and assessment (Actions 4.1 and 7.1), strategies to control point (Action 5.1) and non-point sources (Action 5.2) of pollution to the Yellow Sea, and introduction of new technologies to decrease nutrient loading to the Yellow Sea (Table 5).

| Table 5. Management Actions Related to Water and Sediment Quality.

Action 4.1	Intensive pollution monitoring and assessment.
Action 5.1	Manage land-based point source pollution loads.
Action 5.2	Manage land-based non-point source pollution loads.
Action 5.3	Introduce new technology to reduce nutrients (nitrogen and phosphorus)
Action 7.1	Conduct regular monitoring and assessment and disseminate information, particularly in bathing beaches and other recreational waters.

Monitoring networks have been established on the Chinese (**Figure 6**, C-NSAP, p20) and Korean (**Figure 7**, K-NSAP, p 48) sides of the Yellow Sea for routine monitoring of seawater, marine organisms, and marine sediment[2] (K-NSAP, p 47). The monitoring grid includes sampling in both near-shore open water-areas of the Yellow Sea. As a result, data are presented in spatial terms.

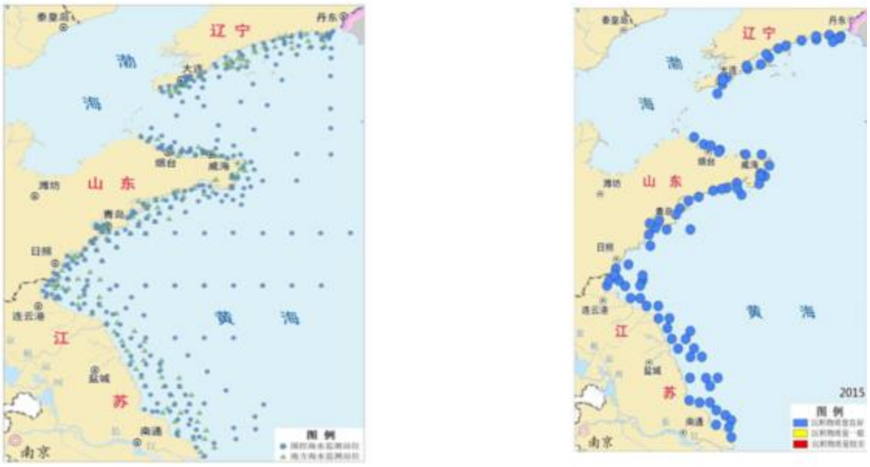


Figure 4-1 Monitoring Sites in Yellow Sea (SOA)
Left: sea water; Right: sediment

Figure 2. C-SAP p 20.

Figure 12. Map of Survey Areas for the Marine Environment Monitoring Network and Screenshot of the Marine Environment Information System (MEIS)

Figure 7, K-SAP p 48.

China publishes the China marine environment status bulletin every year. In this bulletin, the sediment quality monitoring was also carried out. The monitoring indicators include heavy metals, PCB, sulphide and organic carbon and petroleum. According to 2017 China marine environment status bulletin, 100% of the Yellow Sea sediment monitoring sites reached the "good" status. As for seawater, the areas polluted in the YS has been fluctuated between 2001 and 2016. In 2016, the average areas of seawater that had not reached the 1st grade of seawater quality standard was about 34,000 km^2, reduced by 1.5 km^2, the highest polluted sea area dropped by 37%. It is also noticeable of that the main pollutants of the seawater in the YS were inorganic nitrogen, active phosphate and oil (Figure 8). For marine sediment, however, about 91.7% of marine sediment sites in the YS coastal regional had met comprehensive quality grade 1 (good quality) as shown Figure 9 showing the marine sediment quality distribution. The marine sediment quality of the YS was good and annual variations were not significant.

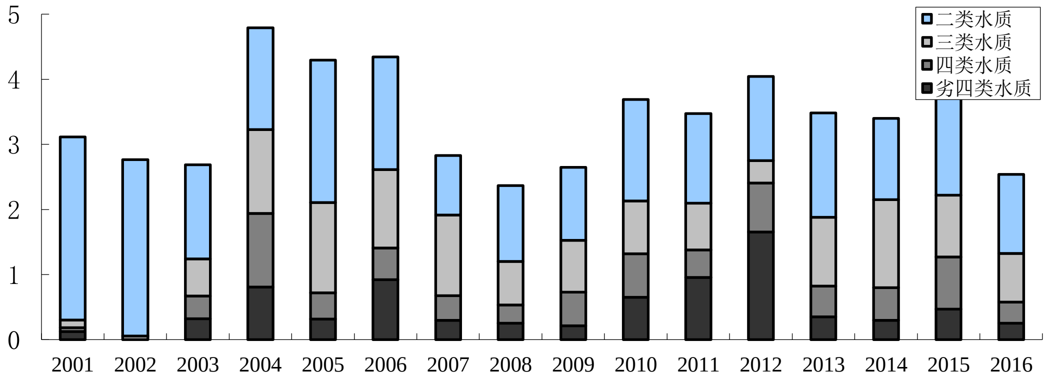


Figure 8. Seawater quality in the YS as a function of time (from ***C-NSAP, p 24***)

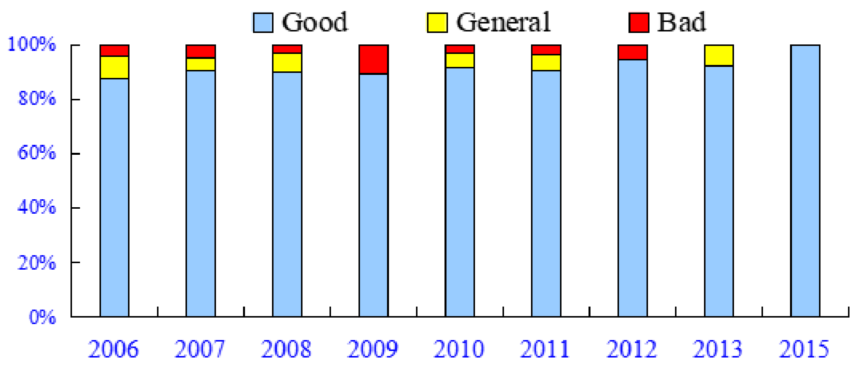


Figure 9. Annual variation of integrated quality of sediments of the YS (2006-2015) (from C-NSAP, p 25)

A second monitoring network is focused at bathing beaches and other recreational areas with similar monitoring and dissemination programs in China (C-NSAP, p 34 – 35) and Korea (K-NSAP, p 95 – 98), This monitoring program is intended to provide up-to-date information, disseminated through web pages and other means, on beach and near-shore weather, pathogens, and biological hazards (e.g., jellyfish). The occurrence of jellyfish blooms has been increasing in frequency and in geographical range, influencing the maritime economy in many ways, causing significant economic losses. Both China and Korea suffered from the influence brought by the jellyfish bloom, so there was long-term international cooperation between two countries. In 2007, the first large scale green tide cause by Ulva broke out in Qingdao coast every year as shown in the Figure 10.

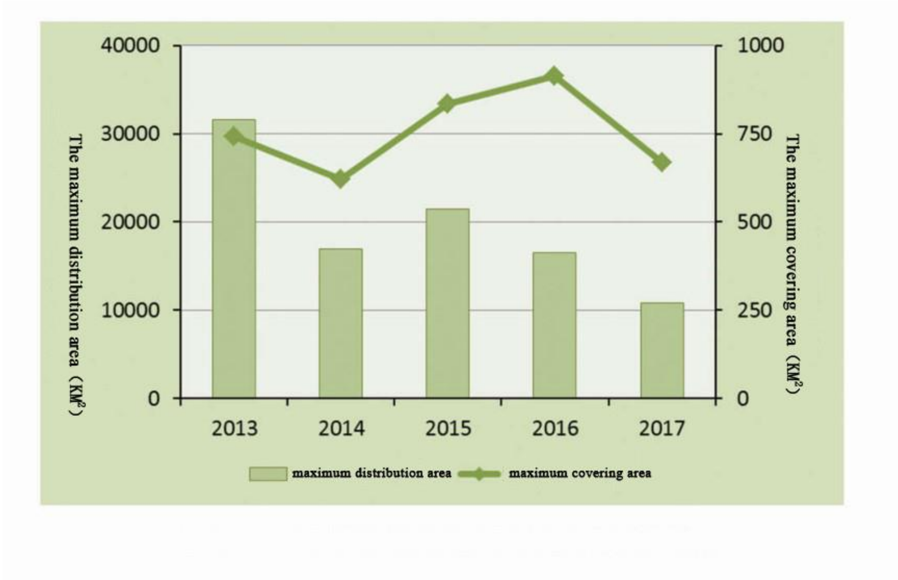


Figure 10. The maximum distribution area and maximum covering area of green tide from 2013 to 2017 in Shandong Province, PR China (from ***C-NSAP, P 48***)

The primary point sources of discharge into the Yellow Sea from both China and Korea are industrial and municipal wastewater from urban areas. In China, the Yellow Sea provinces of Liaoning, Shandong, and Jiangsu are major commercial zones in eastern China and have undergone massive urbanization and industrialization. Municipal and industrial discharges from this region have severely deteriorated water quality. With regard to point source pollution control, emphasis was placed on the regulation of heavy pollution enterprises and the promotion of cleaner production. Local governments have made significant progress. For example, all chemical parks in Jiangsu Province installed automated on-line monitoring devices for wastewater. By the end of 2019, the sewage treatment rates of cities and counties will reach 95% and 85% respectively (C-NSAP, p 27).

Korea has worked to control point-sources of pollution by constructing new wastewater treatment facilities, assuring that new sewage collection systems collect stormwater and wastewater separately (separated systems), and converting combined systems to separated systems. Since 2012, Korea has installed 173 facilities in the Han, Geum and Yeongsan River basins, representing an 8% increase in capacity (K-NSAP, p 61 – 65).

Non-point sources of pollution to the Yellow Sea consist primarily of atmospheric deposition and release of pollutants from agricultural areas. Marine atmospheric monitoring stations have been established in China (C-NSAP, p 27) and Korea (K-NSAP, p 65 and p 70 - 73) and are currently operational. To improve the quality of atmospheric environment, China revised the law on *Prevention and Control of Atmospheric Pollution* in 2018. By the beginning of 2019, China achieved ultra-low emission of coal generating units of about 810 million KW, accounting for 80% of the total installed capacity of coal-fired power plants. The proportion of *excellent* days in 338 cities was 79.3%, an increase of 1.3% over the same period last year, and the PM2.5 concentration was 39 mg/m^3, down 9.3% from the same period last year. Agricultural runoff is the primary non-point source of pollution to the Yellow Sea and releases fertilizers, sediments, herbicides, and pesticides into surface waters. China has a high application rate of fertilizers (22 kg/acre), far in excess of the world average (8 kg/acre), due to limited arable conditions of the soil. The strategy for China is to control the annual growth rate in the use of fertilizer over the period from 2015 to 2020, with the objective of zero growth by 2020 (C-NSAP, p 28).

The approach in Korea for managing non-point sources has been to establish a Total Water Pollutant Load Management System for the river basins contributing to the Yellow Sea. Under this system, the aggregate pollutant load from all non-point sources are considered and managed collectively. Under this system, pollutant concentrations themselves are not regulated. Rather, the party for each pollutant source is allocated a quota for the total allowable mass of pollutants that may be discharged over a specified period of time. The technologies used to achieve these requirements include vegetated swales or buffer strips, wetlands, infiltration trenches, ecological ponds, and detention facilities. After implementation of this management system, the water quality (chemical oxygen demand, COD) improved by 9% to 34% in the three locations monitored (**Figure 11**, K-NSAP, Figure 17, p 68) (K-NSAP, p 65 – 70).

Figure 17. Improvement in Water Quality in Three Areas (Target Expected to Be Achieved in Busan coastal area), Ministry of Oceans and Fisheries (2015)

Figure 11. Improvement in water quality in three areas (target expected to be achieved in Busan coastal area) ***(from K-NSAP, p 68)***

New approaches to nutrient treatment (Action 5.3) consist primarily of upgrading existing industrial and municipal wastewater treatment facilities for more effective nutrient removal and constructing new facilities with these capabilities. These approaches are known as advanced wastewater treatment or tertiary treatment. Technologies include the biological processes of nitrification-denitrification, and biological phosphorus removal, and physico-chemical processes including, coagulation, contact phosphorus removal, reverse osmosis, and selective ion exchange resin removal. The proportion of advanced wastewater treatment facilities in Korea has increased steadily since 2012. Facilities including municipal, industrial, agricultural, livestock and septic systems are included in these upgrades and as of 2016, 74% of all wastewater facilities in Korea apply advanced treatment (K-NSAP, p 74).

2.2.2 Marine Litter

Marine litter can be found on both beaches and in open waters, and has both terrestrial and marine sources. Management actions relevant to marine litter are to minimize generation of marine litter (Action 6.1), improve collection and treatment of marine litter (Action 6-2), and establish a management system for litter (Action 6.3) (Table 6).

| Table 6. Management Actions Related to Marine Litter.	
Action 6.1	Minimize generation of marine litter through the management of original sources of marine litter and solid waste materials.
Action 6.2	Strengthen capacities to collect and treat marine litter.
Action 6.3	Establish management system for litter.

China has been monitoring marine litter on beaches and floating in open water since 2010. Concentrations have fluctuated, however the overall density of marine litter has in 2016 was lower than in previous years. The composition of marine litter in the Yellow Sea is mostly plastic (Figure 12, C-NSAP) and while individual pieces can range widely in size, the most common plastic litter consists of polystyrene foam, plastic bags, plastic bottles and cigarette filters (C-NSAP, p 31.)

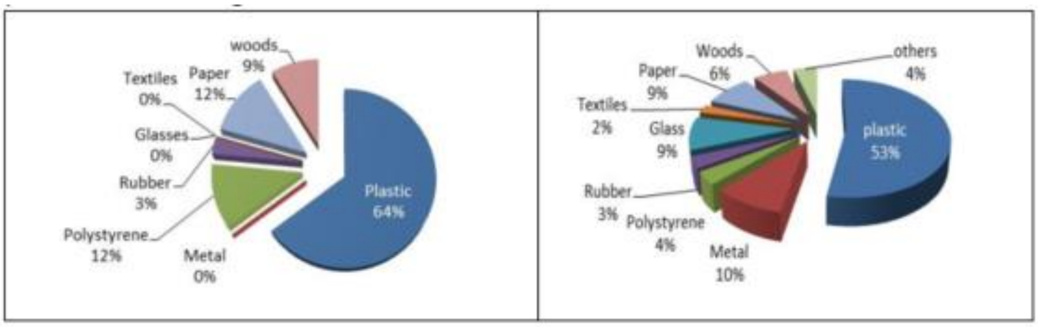


Figure 6-2 Main types of marine litters along the coast of Yellow Sea

(Left: floating litter; Right: Beach litter)

Figure 12. Main types of marine litters along the coast of YS ***(from C-NSAP p 31)***

In 2008, China issued a plastic restriction order to limit the use of disposable plastic bags. To reduce plastic waste input to the eenvironment from ssource, China issued the "Implementation Plan of Domestic Waste Classification System" and launched in 46 pilot cities. Local governments actively carry out river rubbish disposal, establish garbage inspection system, and clean up marine floating garbage.

China actively encourages local governments and NGOs to organize activities for cleaner beaches. Propaganda and Education were carried out to observe World Environment Day, Earth Day, World Oceans Day, International Coastal Clean-up Day and China Ocean Day. On September 17 to 25, 2016, more than 70 social groups, nearly 10 thousand volunteers, organized nearly 40 beach cleaning activities. Special exhibitions on marine debris pollution prevention and control were launched. Volunteer activities for beach cleaning were organized. These methods effectively raise the public's awareness of prevention and control of marine debris (C-NSAP, P***).

Styrofoam buoys have been identified as a main source of marine litter. To control the generation of this waste product (Action 6.1), Korea has begun replacing Styrofoam buoys with biodegradable eco-friendly buoys, and collecting the Styrofoam buoys. As a result of such efforts, Korea has collected between 200,000 and 400,000 tonnes of marine litter every year (K-NSAP, p 77).

Efforts in Korea to collect and treat marine litter (Action 6.2) have included installation of floating marine litter collection platforms, clean-up projects in ports and areas designated for environmental conservation, and a buy-back program for litter recovered during fishing operations. Other projects include improvement projects for recreational fishing areas and collection and disposal of disaster waste. Since 2008, the total annual amount of marine litter collected in all Korean waters (not limited to the Yellow Sea) ranged from about 25,000 tonnes per year to 123,000 tonnes per year. In 2018, the amount collected was 30,000 tonnes (K-NSAP, p 84 – 88).

In 2011, Korea established a Marine Litter Management Center (MALI). This organization has been collecting and analysing information on overall marine litter management (Action 6.3). One function of MALI is to propose research and policy measures to address the issue of marine litter in a comprehensive and scientific manner (K-NSAP, p 89 – 90).

2.2.3 Contaminants

The discharge of toxic pollutants in the marine environment can result in the violation of one or more international standards or conventions (Table 7).

| Table 7. Management Actions Related to Contaminants.	
Action 4.2	Comply with international standards for regulating toxic organic pollutants.
Action 4.3	Implement international agreements regarding regulations on oil and hazardous and noxious substances (HNS).

China and Korea are both have aligned with the Codex *Alimentarius* and the Stockholm Convention. The Codex *Alimentarius* Commission (CAC) was established in 1963, by the United Nations Food and Agricultural Organization (FAO) and the World Health Organization (WHO), to establish a set of international standards for contaminants in food. China formally joined the CAC in 1984 and Korea[3] joined the CAC in 1971. The Stockhom Convention on Persistent Organic Pollutants requires signatory countries to reduce or eliminate persistent organic pollutants (POP) in the environment. China signed the convention in 2001 (Entry into Force in 2004) and Korea signed[4] the convention in 2007 (Entry into Force in 2007) (C-NSAP, p 23).

Since entering into the Stockholm Convention, China has undertaken a wide range of activities, including elimination of production of a large number of POPs, developed alternative technologies, and prohibited the production, circulation, use, and import or export of DDT, chlordane, and mirex (except for vector control and emergency use) (C-NSAP, p 23 – 24).In April 2007, the State Council of China approved the "National Implementation Plan" (NIP) of China. Since the NIP was carried out, China has made progress and solved a number of environmental hazards of POPs that seriously threaten human health and safety. Firstly, the production, use, import and export of the initial group of intentionally produced POPs has been stopped, the content level of which in the environmental and biological samples has an overall downward trend. Secondly, the emission intensity of Dioxins in key sectors such as iron ore sintering, secondary non-ferrous metal smelting, and waste incineration has decreased by more than 15%. Thirdly, over 50,000 tons POPs-containing legacy waste has been cleaned up and disposed. In December 2018, China updated the NIP, specifically for the Convention implementation of the 11 new POPs, and submitted to Secretary of the Convention.

Korea has adopted the criterial proposed in the Stockholm Convention into the POPs Control Act and Marine Environment Management Act to provide the basis for POPs management efforts. In addition, POPs monitoring networks have been established and operated to monitor the status and trends of pollution in the marine environment. In addition, the Korean government is working to reduce emissions by designating a national dioxin emission rate, based on studies of POPs emission sources and amounts, and strengthening the management of POPs emitting facilities (K-NSAP, p 50 – 53).

Pollutant discharges from ships are regulated by the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78). The objective of this convention is to eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances. To comply with MARPOL

73/78, China adopted several regulations to control discharge of ballast waters and other emissions from ships (C-NSAP, p 25).

Korea adopted two protocols related to toxic discharges at sea: the International Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC) and the Protocol on Preparedness, Response, and Co-operation to Pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS). Activities included providing contingency plans regarding oil pollution for vessels and marine facility, reports and notifications regarding oil spills, and national and regional systems to respond to and address oil spills (K-NSAP, p 54).

2.3 Ecosystem Changes

From an ecological perspective, ecosystem changes can occur from both the "top down" and the "bottom up". As described previously, top-down changes occur, for example, when fishing pressure removes or depletes a particular species occupying a high trophic level, and other competing species replace it. Bottom-up changes can occur when supplies of nutrients change and the structure of primary producers is altered. Both processes occur simultaneously in the Yellow Sea and the ecosystem is additionally affected by other driving forces, which include climate change impacts. Management Goal 8 of YSLME SAP Implementation calls for *better understanding and prediction of ecosystem changes for adaptive management*.

2.3.1 Nutrient Ratios

Water quality monitoring programs described previously in Section 3.2.1 provide data on nutrient ratios in coastal and pelagic waters of the Yellow Sea (Table 8). China's monitoring stations, for example, are shown in Figure 13. (Figure 2.1, C-NSAP, p 37).

| Table 8. Management Actions Related to Nutrient Ratios.

Action 8.1	Monitor and evaluate the effects of the ratios of nitrogen, phosphorus, and silica.

Concentrations and ratios of three key nutrients: nitrogen, phosphorus, and silica, have a strong influence on the abundance and diversity of primary producers (phytoplankton, zooplankton, and macro-algae) that form the base of the food chain. Ecosystems that are considered healthy, have a higher relative abundance of diatoms. These single-celled plankton have skeleton-like internal structures, and therefore require certain amounts of dissolved silica in their environment. Concentrations and ratios of nitrogen and phosphorus can govern whether or not harmful algae blooms will occur.

Figure 13, (Figure 2.2 – 2.4, C-NSAP) shows changes in Yellow Sea nutrient concentrations from 2005 to 2017. Figure 14, (Figure 29, K-NSAP, p 106) for example, shows systematic decline in the ratios of both N:P and Si:P in the western YSLME Korea's, due to river discharge effects. It is not yet known if these changes are part of a long-term trend, or instead are a temporary fluctuation. However, these changes may be expected to drive higher trophic-level ecosystem changes (K-NSAP, p 103 – 106).

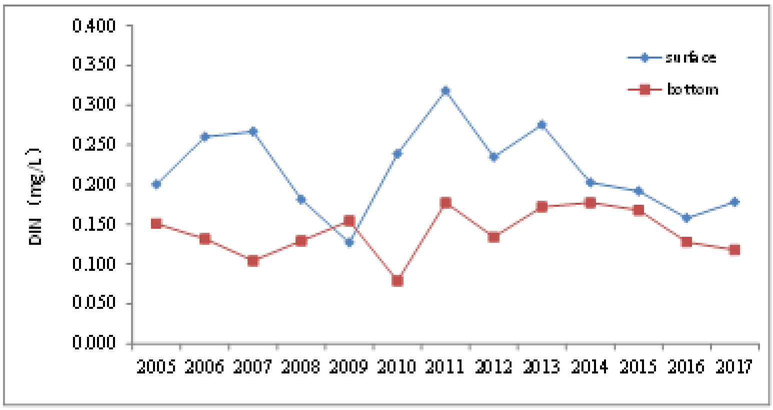


Fig.2.2 Interannual change of DIN in Yellow Sea, both surface and bottom.

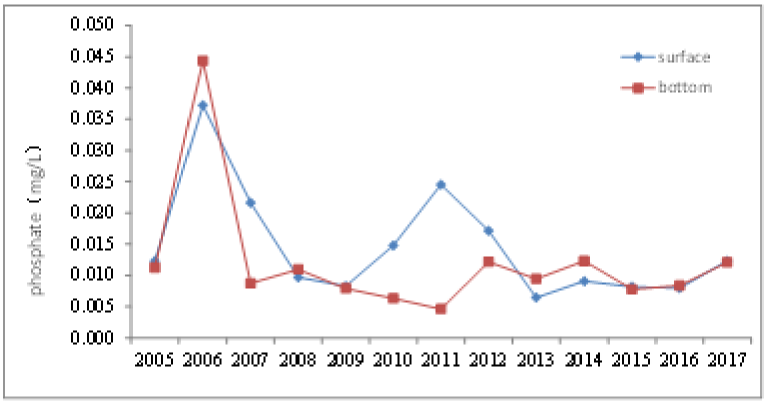


Fig.2.3 Interannual change of phosphate in Yellow Sea, both surface and bottom.

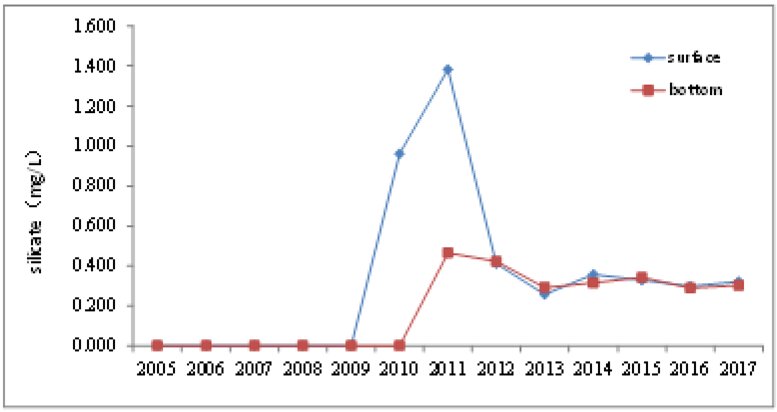


Fig.2.4 Interannual change of silicate in Yellow Sea, both surface and bottom.

Figure 13. Interannual changes of silicate in YS both surface and sediment ***(from C-NSAP Figure 2.2 – 2.4).***

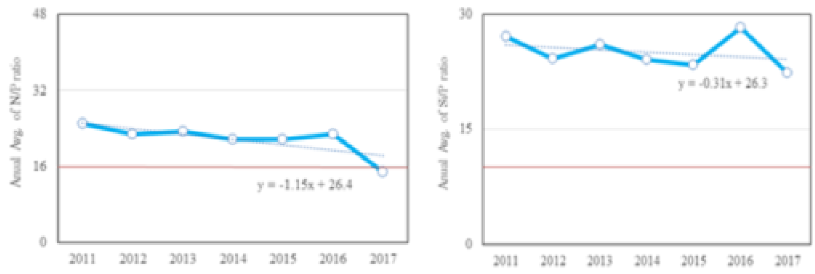


Figure 29. Inter-annual variation of N:P Ratio (left) and Si:P Ratio (right) in Korea's West Sea. Ratios were obtained from the data collected through the National Marine Environment Monitoring Network.

Figure 14. Inter-annual variation of N:P ration and Si:P ratio in Korea's west sea ***(from K-NSAP, p 106)***

2.3.2 Blooms of Nuisance Species

Blooms of jellyfish and harmful algae are indicators of ecosystem change are themselves the cause of economic and health problems. Monitoring and evaluating the extent of these blooms are the objectives of Actions 8.4 and 8.5 (Table 9).

Table 9. Management Actions Related to Blooms of Nuisance Species.	
Action 8.4	Monitor and evaluate the transboundary impact of jellyfish blooms.
Action 8.5	Monitor the appearance of harmful algae blooms (HABs).

The occurrence of jellyfish blooms has been increasing in frequency and geographical range, influencing the maritime economy in many ways. Increasing incidents of jellyfish stinging adversely affects coastal tourism. Jellyfish can block cooling systems in industrial cooling intakes, causing significant economic losses. At the ecosystem level, jellyfish blooms alter the function of marine ecosystems and may cause catastrophic regime shifts in the ecosystem (C-NSAP, p 43).

To monitor and evaluate jellyfish populations, China undertook the National Basic Research Program on Giant Jellyfish Blooms in Chinese Seas, from 2011 to 2015. The main tasks of the project were to understand the controlling factors, key processes, and driving mechanisms in jellyfish blooms in Chinese coastal waters; to discover how jellyfish blooms influence the marine ecosystem and their mechanisms of causing harm,; and evaluating ecologic disasters and how to put into place mitigating measures (C-NSAP, p43).

In Korea, the NIFS and KIOST have been developing measures to reduce damage caused by jellyfish blooms through the Study on the Causes of and Countermeasures against Jellyfish Blooms. In addition, they have established a system for monitoring the annual appearance of Nomura's jellyfish in littoral seas (Figure 15).

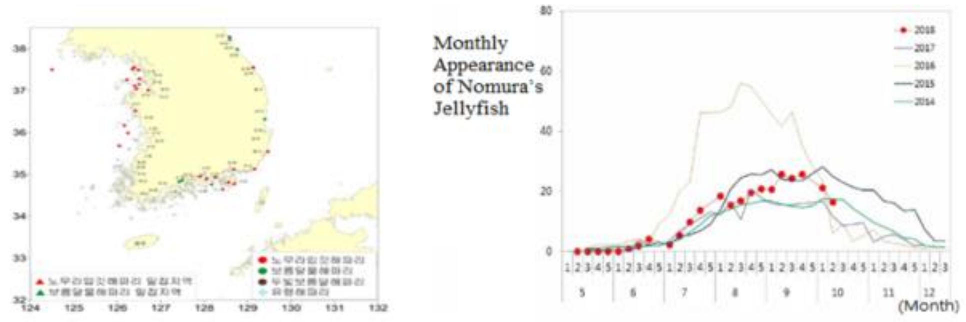


Figure 34. Weekly appearance of Nomura's Jellyfish (red dot), Moon jelly (green dot) and other (left) and annual variation of appearance rate of Nomura's Jellyfish in 2014-2018 (right)

Figure 15. Weekly appearance of Nomura's jellyfish (red dot), Moon jelly (green dot) and other (left) and annual variation of appearance rate of Nomura's jellyfish in 2014-2018 (right) **(from *K-NSAP, p 113.* Figure 34, K-NSAP, p 113).**

The causes of harmful algae blooms are complex, but necessary preconditions include nutrient enrichment, and in the case of the Yellow Sea, low relative silica concentrations that favour harmful algae over diatoms. Adverse effects include the nuisance presence of the algae, local oxygen depletion, and the release of toxins that can be fatal to wildlife and humans. Common forms of HAB are known variously as green tide (e.g., *Ulva* or *Enteromorpha* blooms), golden tide (blooms of the brown macro-algae, *Sargassum*), and red tide (generally, blooms of dinoflagellate algae, but species can vary).

The occurrence and distribution of HABs has changed over the past decade. Green tides consisting of *Enteromorpha prolifera,* have bloomed continuously on the west coast of the YSLME in China. It is anticipated that the increased primary productivity associated with green tides will result in an overall increase in organic nitrogen in the YSLME. Red tides have been observed to decline in frequency, but to have an increased proportion of toxic species. (Zhang, 2018, YSLME 3rd Science Conference, Keynote Presentation).

China started research on HABs in the 1970s. In 2007, the first large scale bloom of Ulva broke out along the Qingdao coast. From then on, green tide affected this area annually. In May to July 2017, green and golden tides occurred along the south coast of the Shandong Peninsula, consisting of *Ulva* and *Sargassum*. Of economic importance, in December 2016, a seaweed farming area of *Poryphyra yezoensis* in the Jiangsu Shoal of the Yellow Sea was severely affected by *Sargassum horneri* (Figure 16). At the sites severely affected by drifting *Sargassum*, the Poryphyra aquaculture facilities were taken over by *Sargassum* and collapsed. This caused the largest direct economic loss caused by floating *Sargassum* in China, with estimated losses of 500 million CNY (about USD $73 million) (C-NSAP, p 42 – 43).

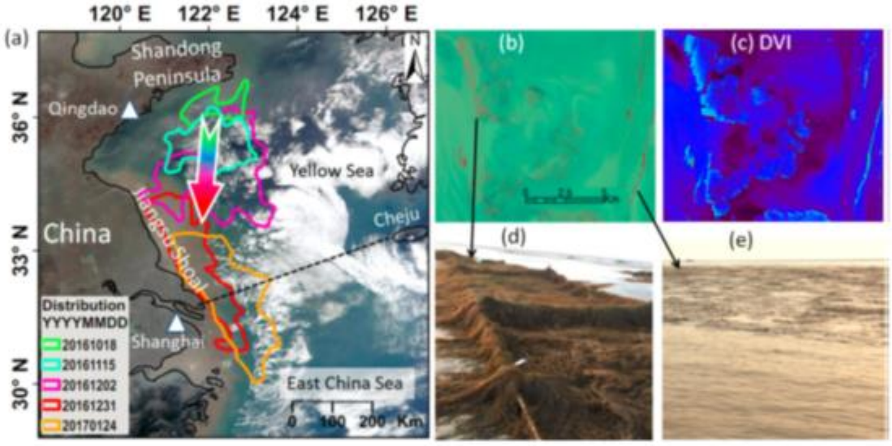


Fig.2.12 (a) Southward drifting path of Sargassum patches from October 2016 to January 2017. The background image is a true-color composite by MODIS bands acquired on December 31, 2016. (b) False-color image over the Jiangsu Shoal on the same day, which is a composite of GF-1 band 4(R), band 3(G),and band 2(B); the regularly distributed red strips are the seaweed aquaculture rafts while the irregular red slicks or patches are floating Sargassum. (c) Image of DVI that ranges from −0.090 to 0.076. (d) and (e) In situ photographs of Sargassum covering the seaweed facilities and in the turbid waters, respectively.(Xing et al., 2017)

Figure 16. Southward drifting path of Sargassum patches from October 2016 to January 2017 ***(from Figure 2.12, C-NSAP, p 46)***

Since 1997, through the efforts of NIFS, Korea has been regularly monitoring HABs in the West Sea, as part of the project, Study on HABs Monitoring and Outbreak Mechanism. The results of this project were analysed in correlation with water quality data collected through environmental monitoring of fishing grounds to identify conditions that cause red tides and long-term ecosystem shifts. Additionally, the NIFS has regularly conducted HABs monitoring using survey vessels and ships of opportunity. As of 2017, there were 82 HAB monitoring stations in the Yellow Sea, and nine surveys have been conducted. Monitoring in the coastal waters of the West Sea indicates that the number of occurrences of HABs began declining after 2014 and no red tides occurred in 2016 and 2017 (Figure 17).

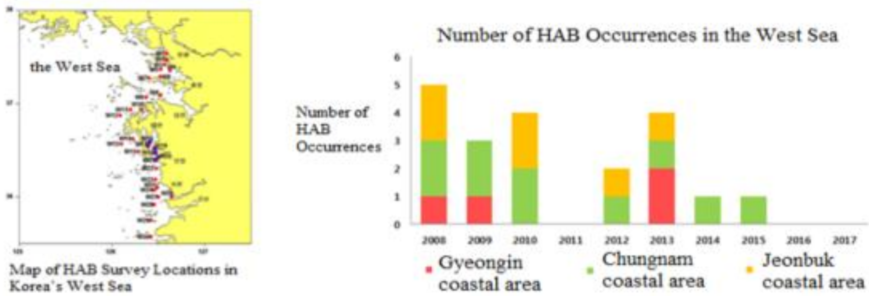


Figure 37. Map of HAB Survey stations in Korea's West Sea and Number of HAB Occurrences in the West Sea (2008-2017)

Figure 17. Map of HAB survey stations in Korea's west sea and number of HAB occurrences in the west sea (2008-2017) ***(from Figure 37, K-NSAP, p 119 – 120).***

International cooperation between Korea and China includes information exchanges and workshops on red times, in order to promote the monitoring of HABs and their impacts. Activities include the East Asian Harmful Algae Bloom Research Group (EASTHAB), which was launched in 2004, with biannual meetings. EASTHAB promotes research on HABs occurrence mechanisms and countermeasures in East Asia by sharing information and research results on HABs in Korea, China, Japan, and the Philippines (K-NSAP, p 117 – 118).

2.3.3 Climate Change Effects

Climate change has profound effects on ecosystems, either as a direct driver or through indirect mechanisms. The YSLME Phase II SAP Implementation project directly addressed climate change impacts specifically on lower trophic levels of the Yellow Sea ecosystems (Action 8.2), and generally in the prediction of long-term changes in Yellow Sea ecosystems (Action 8.3) (Table 10). Concerns related to climate change include rising sea-surface temperatures, sea-level rise, and ocean acidification. These abiotic changes can cause diverse impacts on ecosystems, including northward distributions of warm-water species, acceleration of primary productivity, and alterations of trophic structures.

| Table 10. Management Actions Related to Climate Change Effects.

Action 8.2	Monitor and evaluate the lower trophic level effects of climate change.
Action 8.3	Predict long-term changes of the Yellow Sea's ecosystem due to climate change.

Sea-surface temperatures have been increasing in the Yellow Sea in recent decades. Figure 18 (Figure 2.14, C-NSAP, p 47) shows mean annual sea-surface temperature (SST) anomalies in coastal China from 1870 to2017 (Pei, et al., 2017).

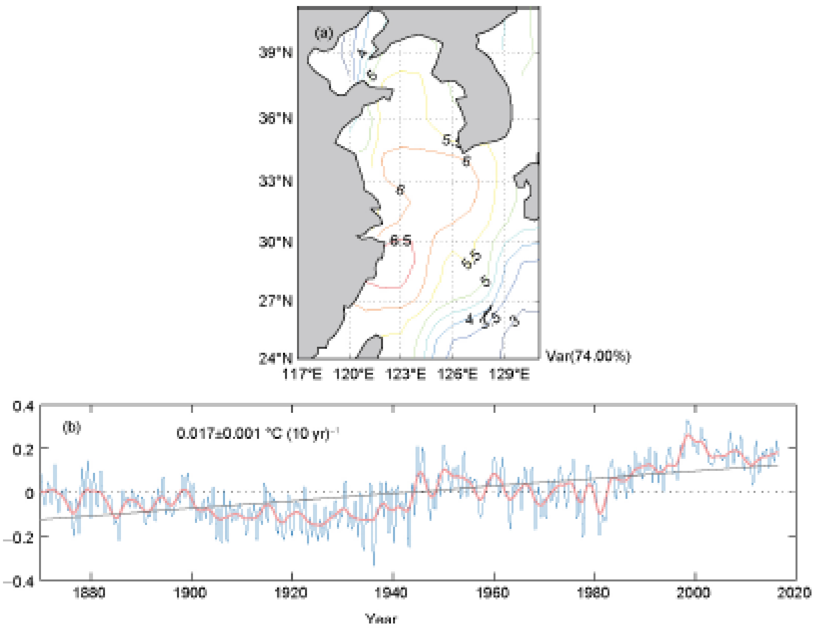


Figure 1 First EOF mode for SST anomalies in the Yellow Sea and East China Sea: (a) spatial mode, (b) temporal mode. The bold pink curve in (b) indicates the 2-year moving average result and the grey line indicates the trend, which is specified in the bottom panel. The increasing rate is specified in (b), and the '±' indicates the 95% confidence interval of the rate. The annual and intra-annual signals (f>0.8 cycle yr^{-1}) are all filtered out prior to EOF analysis.

Figure 18. First EOF mode for SST anomalies in the YS and East China Sea ***(from Pei, et al., 2017).***

This trend of increasing sea-surface temperatures (SSTs) can be seen in the spatial increase in the water temperatures of the YSLME. Figure 19 shows increases in water temperatures during the month of August in 2005 compared with 2018 in the northern YSLME and the Bohai Sea. The China Sea Level Bulletin (2018) reports that from 1980 to 2018, the sea surface temperatures of China's coastal waters increase by 0.23°C over the ten-year period.

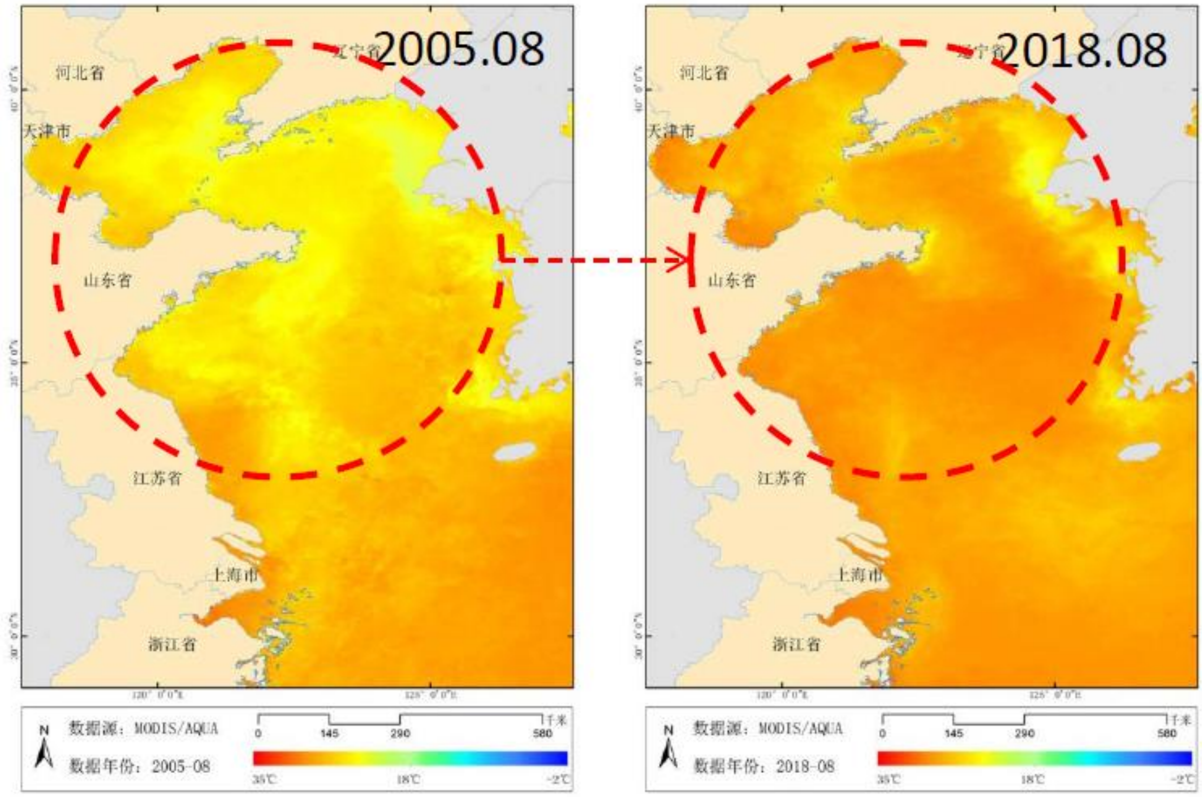
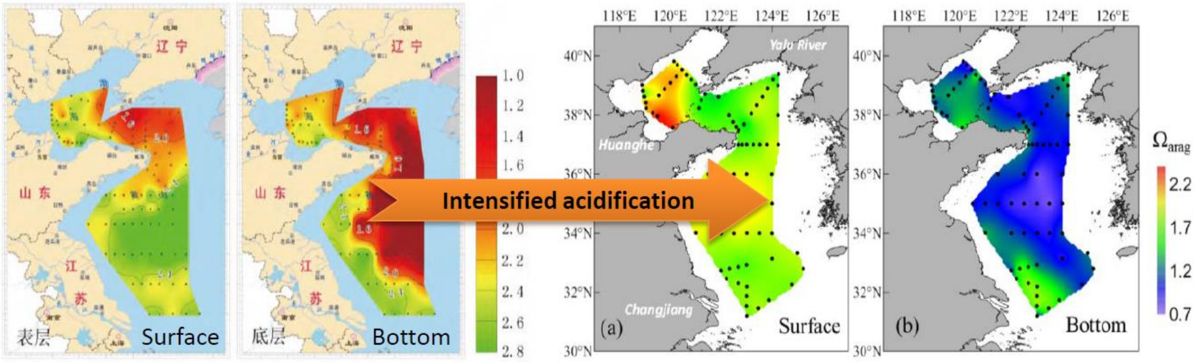


Figure 19. Sea-surface temperatures in the Bohai Sea and upper YSLME ***(Reproduced from Zhang, 3rd Science Conference Keynote Presentation).***

Increased atmospheric CO_2 levels, is being observed to cause a loss of alkalinity in ocean waters worldwide. Marine acidification affects bio-calcification rates, primary productivity, nitrogen fixation, and species reproduction, especially for the shell formation process of calcareous organisms. Increased acidification in the waters of the YSLME has been modelled to the year 2100. In a modelling study of marine acidification, Zhao et al. (2018) predicted spatial patterns of decreased alkalinity (Figure 20), particularly in the bottom waters of the YSLME.



Distribution of Calcium Carbonate Saturation
Aug. 2012

Prediction of distribution of Calcium Carbonate Saturation
Aug. 2100

Figure 20. Spatial distribution of calcium carbonate saturation in the YSLME, in surface and bottom waters in 2012, compared with predictions for conditions in 2100 ***(Reproduced from Zhang, YSLME 3rd Science Conference.)***

According to research conducted in the northern Yellow Sea, the plankton structure has greatly changed from 1959 to 2011. Some warm water species, such as *Sagitta enflata* and *Doliolum denticatum*, which were distributed in the south of Yellow Sea in 1959, are now distributed in the northern Yellow Sea and became the dominant species (Zou et al, 2013) (C-NSAP, p 47.)

Dynamic bioclimate envelope model (DBEM) predict changes in the abundance and distribution of Japanese anchovy in response to climate change. Chen (2014) modelled the interannual variations in resource density, and distribution of the anchovy, a key species in the food web of the Yellow Sea. Under four climate-change scenarios with varying assumptions on atmospheric CO_2 concentrations, the wintering anchovy stock showed a clear northward trend, by as much as 2.7 degrees latitude in the next 30 years (Figure 21).

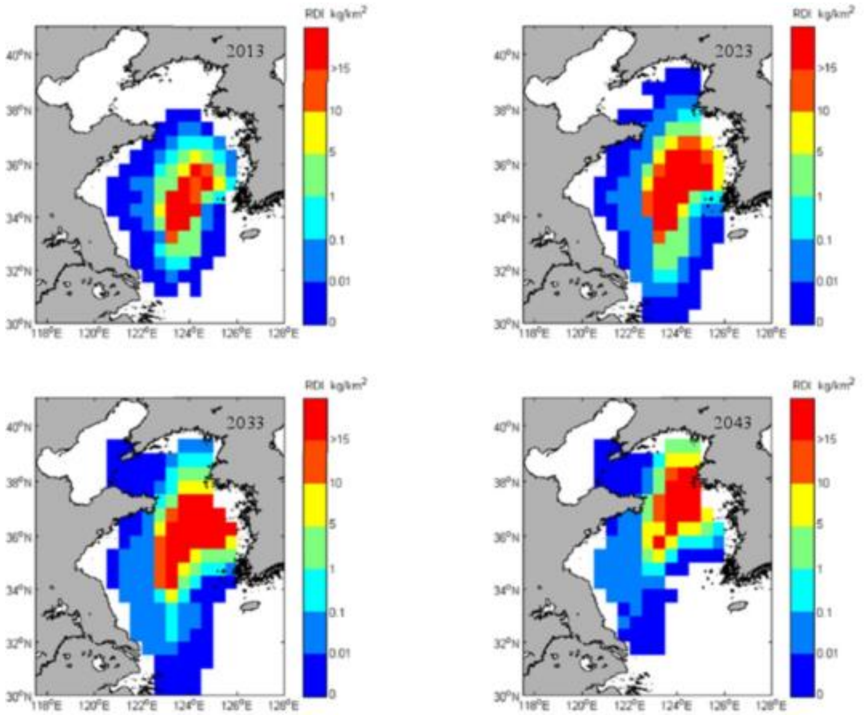


Fig 2.6 Distributions of anchovy under RCP2.6 scenarios in the year 2013, 2023, 2033 and 2043. RDI is Resource Density Index. (Chen, 2014)

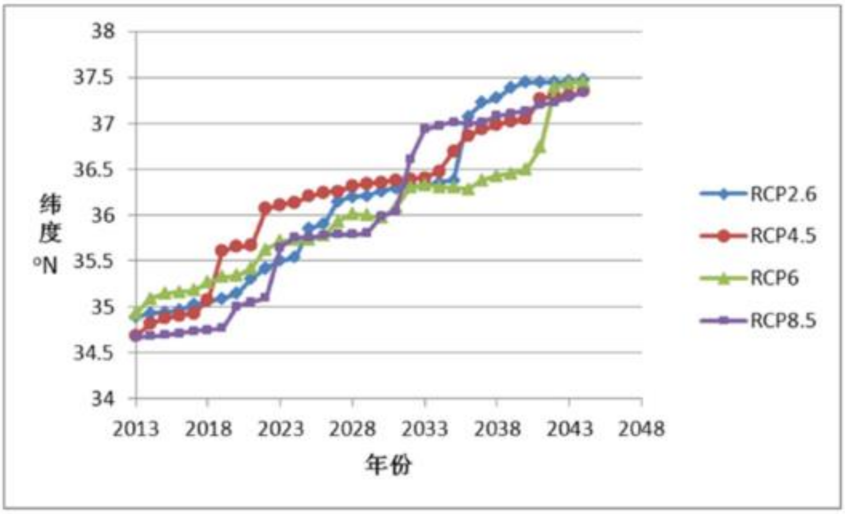


Fig. 2.7 Redistributions of wintering anchovy under different scenarios. (Year vs Latitude)(Chen, 2014)

Figure 21. Redistributions of wintering anchovy under different scenarios ***(from Figures 2.6 and 2.7, C-NSAP, p 40 – 41)***

Ecosystems are sufficiently complex that predictions of changes in trophic structures due to climate change are not possible with numerical models alone. KIOST has undertaken mesocosm experiments to assess the impact of climate change on marine ecosystems. An example of the results of an experiment in which algal growth rates are monitored under different CO_2 concentrations is shown in Figure 22.

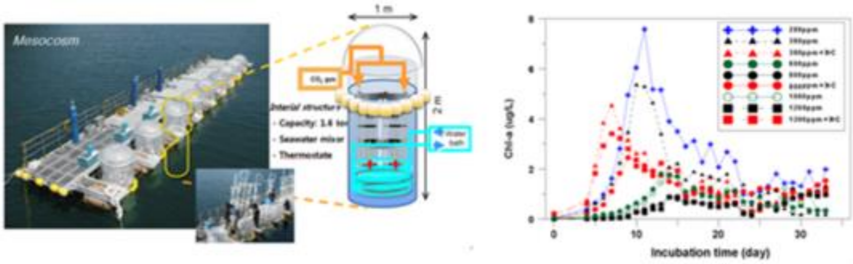


Figure 31. A Photo and specification of KIOST self-produced Mesocosm System, which mimics the natural condition except CO_2 conditions, to assess the impact of Climate Change on marine ecosystem. An example of the results (algal growth rates under different CO_2 condition) obtained from a mesocosm experiment was presented.

Figure 22. A photo and specification of KIOST self-produced Mesocosm system ***(from K-NSAP, p 109).***

Also need to include in this section:

- *Relevance of UNFCCC compliance activities.*
- *As suggested in the paragraph above, the implications for climate change on disaster preparedness and sea-level rise in YSLME coastal areas.*

2.4 Biodiversity

Habitat loss, including degradation and fragmentation, is the most important cause of biodiversity loss globally. Natural habitats in most parts of the world continue to decline in extent and integrity, although there has been significant progress to reduce this trend in some regions and habitats. Reducing the rate of habitat loss, and eventually halting it, is essential to protect biodiversity and to maintain the ecosystem functions essential to supporting human livelihoods.

2.4.1 Coastal Wetlands and Reclamation

Preserving and restoring coastal wetlands are essential elements in the protection of Yellow Sea ecosystems. Wetlands are nurseries for key aquatic species in the Yellow Sea, are critical habitats for migratory water birds, and are intense zones of nutrient cycling, Located at the interface between land and sea, these wetlands also compete with human interests for development, and therefore are on the front lines of reclamation projects. Management actions in the YSLME Phase II SAP Implementation project related to coastal wetlands involve developing management plans for the preservation of coastal habitats (Action 10.1) and for controlling reclamation demand (Action 10.3) in the coastal areas of the Yellow Sea (Table 11).

| Table 11. Management Actions Related to Coastal Wetlands.

Action 10.1	Supplement and effectively implement plans for coastal management areas and develop guidelines for the preservation of coastal habitats.
Action 10.3	Control new coastal reclamation demand and implement proper management strategies.

Intensifying human activity, primary reclamation projects, has resulted in severe wetland loss. Compared with the 1980s, the YSLME lost 9,700 km^2 of sea area, with 40% of total natural tidal flats lost (Yim, et al. 2018) (Figure 23).

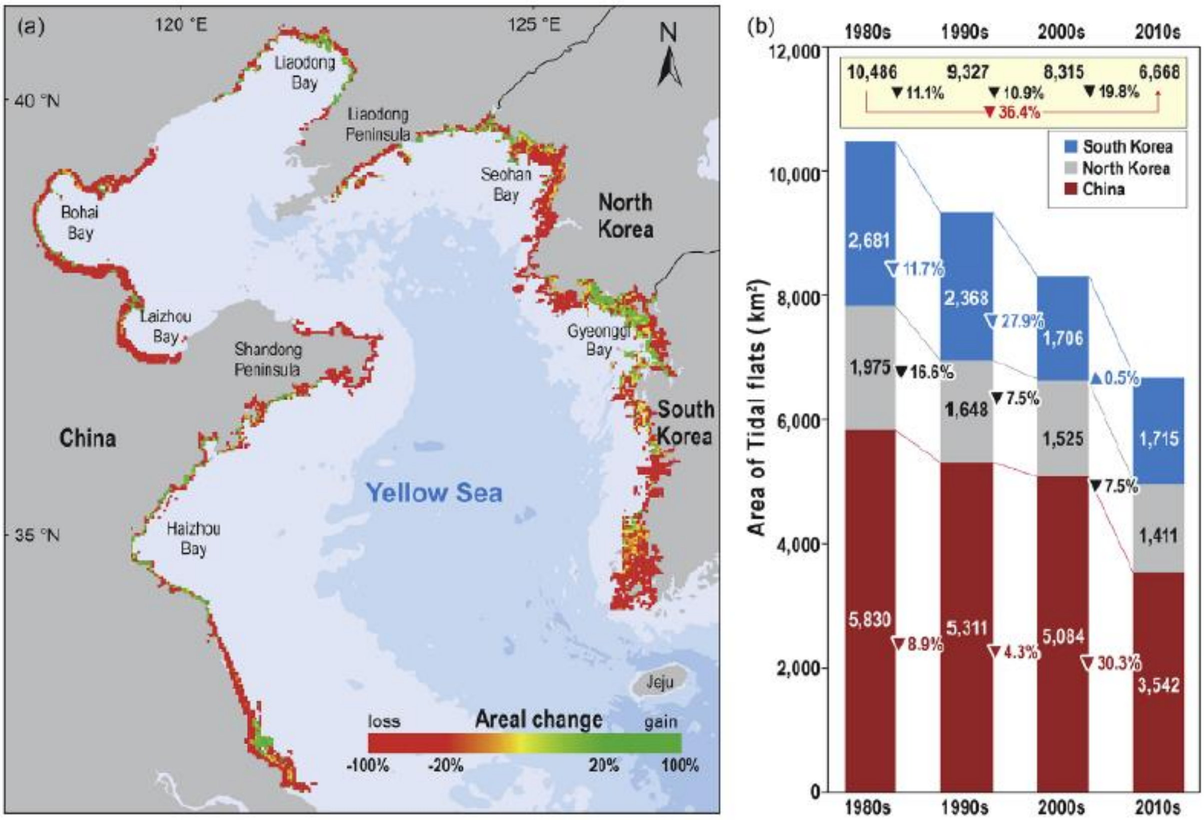


Figure 23. Areal change in the tidal mudflats from the 1980s to the 2010s ***(Reproduced from Zhang, YSLME 3rd Science Conference keynote presentation)***

China and Korea are both taking action to preserve and restore these critical habitats. According to China's Second National Wetland Survey, the coastal areas of the Yellow Sea account for just over 11% of the total wetlands in China. Of the 49 wetlands in China designated as International Important Wetlands, two are in the Yellow Sea region: The National Nature Reserve for Rate Birds in Yancheng, Jiangsu and the National Nature Reserve for David's Deer in Dafeng, Jiangsu (C-NSAP, p 51 – 52).

China has launched several wetlands conservation projects to mitigate the impact of reclamation and prevent habitat loss. According to the redline policy, over 19,000 km^2 of coastal area in Liaoning, Shandong and Jiangsu provinces were designated as Development Restricted Zones (DRZs) or Development Prohibited Zones (DPZs). All construction activities are banned in DPR areas, and construction is strictly controlled and reclamation is prohibited in DRZ areas. There is an increasing number of protected wetlands in the Yellow Sea coastal area of China. Prior to 2007 there were three protected wetlands occupying 3,870 km^2. As of 2017, that number had grown to nine wetlands occupying 4,220 km^2 (C-NSAP p 51 – 53). And finally, China's 2018 moratorium on coastal reclamation went into effect in 2018. The moratorium is intended to demolish illegally reclaimed land and to stop approving general reclamation projects.

Article 6 of Koreas Coast Management Act requires a national integrated coastal management plan every ten years at the national level (Article 6) and at the local government levels (Article 8). Management goals associate with the national plan include systematic management of all natural shores, mudflats, and coastal habitats. Mudflats, like coastal wetlands, are key habitats for shellfish, invertebrates, and migratory waterbirds along East Asian – Australasian Flyway. Monitoring efforts from 2003 to 2013 by local governments indicate that the total area of mudflats along the Korean coast of the Yellow sea generally appears to be increasing. However this monitoring program also recorded losses in mudflat areas to reclamation projects for agriculture expansion (Gimpo and Gyeonggi-do) and development of a fishing port (Jeongok Port) and industrial complexes (Chungcheongnam-do).

2.4.2 Priority Endangered and Threated Migratory Species

The coastal wetlands and mudflats described previously are some of the key habitats for priority endangered and threatened species in the Yellow Sea Large Marine Ecosystem. It is additionally essential to protect endemic species and marine organisms (Action 9.1) in the Yellow Sea (Table 12).

| Table 12. Management Actions Related to Priority Endangered and Threatened Migratory Species.

Action 9.1	Conserve the genetic diversity and population of endemic species and marine organisms under protection and develop regional guidelines.

The wetlands of the Yellow Sea are critical to the survival of many migratory waterbirds using the East Asian – Australasian Flyway (EAAF), by providing staging and over-wintering habitats. The China Yellow (Bo hai) Sea migratory bird habitat in Yancheng, Jiangsu Province has been recently listed as a UNESCO World Heritage site at the 43rd session of the World Heritage Committee. The Yancheng wetland is critical to the survival of many migratory waterbird species using the East Asian-Australasian Flyway (EAAF), by providing staging and over-wintering habitats for migratory waterbirds. During early winter, thousands of birds can be found in Yancheng area, either low flying or searching for food in great numbers.

A total of 3,941 black-faced spoonbills were recorded in the 2018 Global Black-faced Spoonbills, which was co-ordinated by the Hong Kong Bird Watching Association. The number of black-faced spoonbills in mainland China reached 744, an increase of 187% compared with 2017, China became the second largest habitat in the world for black-faced spoonbill. (Sources: http://news.sina.com.cn/o/2018-03-28/doc-ifyssrri4817579.shtml)

The Xiaoyangkou, Jiangsu wetland is one or the most important habitats for waterbirds in the Yellow Sea, according to a 2016 study of the Institute of Geographical Sciences and Natural Resource Research of the Chinese Academy of Sciences. It is critical to the survival of many migratory waterbird species using the EAAF. It is the staging and over-wintering habitats for migratory waterbirds, and home to about 370 species of birds recorded in this area. Some critically endangered species like the spoon-billed sandpiper, Baer's Pochard and white crane, can be found in the area, too, according to the International Union for Conservation of Nature Red List of Threatened Species 2015 (C-NSAP, p 54).

Through the efforts of the Korean Ministry of Oceans and Fisheries, the Korean Ministry of Environment, NGOs, and other relevant organizations, projects have been undertaken to protect endangered marine organisms. These include rescuing sea turtles; securing the basis for marine life to reproduce indoors; protecting the habitat, and restoring the populations, of marine species under protection; and raising public awareness of the protection and management of marine life (K-NSAP, p 123 – 124).

Other efforts undertaken by both China and Korea involve protecting the spotted seal, which as adults inhabit the ice floes of the north Pacific Ocean and adjacent seas. However, Liaodong Bay in the upper reaches of the Yellow Seas serves as a breeding area for the spotted seal. Historically the spotted seals were abundant, with more than 8,000 in the 1940s. Over-hunting and wetland loss resulted in a dramatic decrease in populations. China listed it as a second-class protected species and the National Nature Reserve for spotted seal in Dalian was designated in 1992. By 2007, the number of spotted seal was 890. Conservation efforts have resulted in an increase in numbers, with 2,000 spotted seal counted in 2015 (C-NSAP, p 54 – 57).

Korean surveys of spotted seal populations have been underway since at least 2002. In 2006 a survey of the habitat conditions of spotted seals in Baengneyong Island (Ministry of Oceans and Fisheries), and a survey of the habitat conditions by the Han River Basin Environmental Office (Ministry of Environment). In addition to reports of annual populations, a service proving real-time video of the spotted seal habitat on Baengneyong Island was launched (Figure 24).

Figure 38. real-time video service of the spotted seal habitat on Baengneyong Island

Figure 24. Real-time video service of the spotted seal habitat on Baengneyong Island ***(from Figure 38, K-NSAP, p 124)***

2.4.3 Marine Protected Areas

Marine Protected Areas (MPAs) provide the refuges necessary for the conservation of wetlands and other critical habitats for rare and endangered species and other important marine organisms. China and Korea have undertaken systematic efforts to expand and manage MPAs and establish networks of MPAs (Action 10.2, Table 13).

| Table 13. Management Actions Related to Marine Protected Areas.	
Action 10.2	Expand and effectively manage marine protected areas (MPAs) and establish a network of MPAs.

While progress has been made in creating MPAs, the areas available for rare, endangered, and protected species is inadequate (Figure 25).

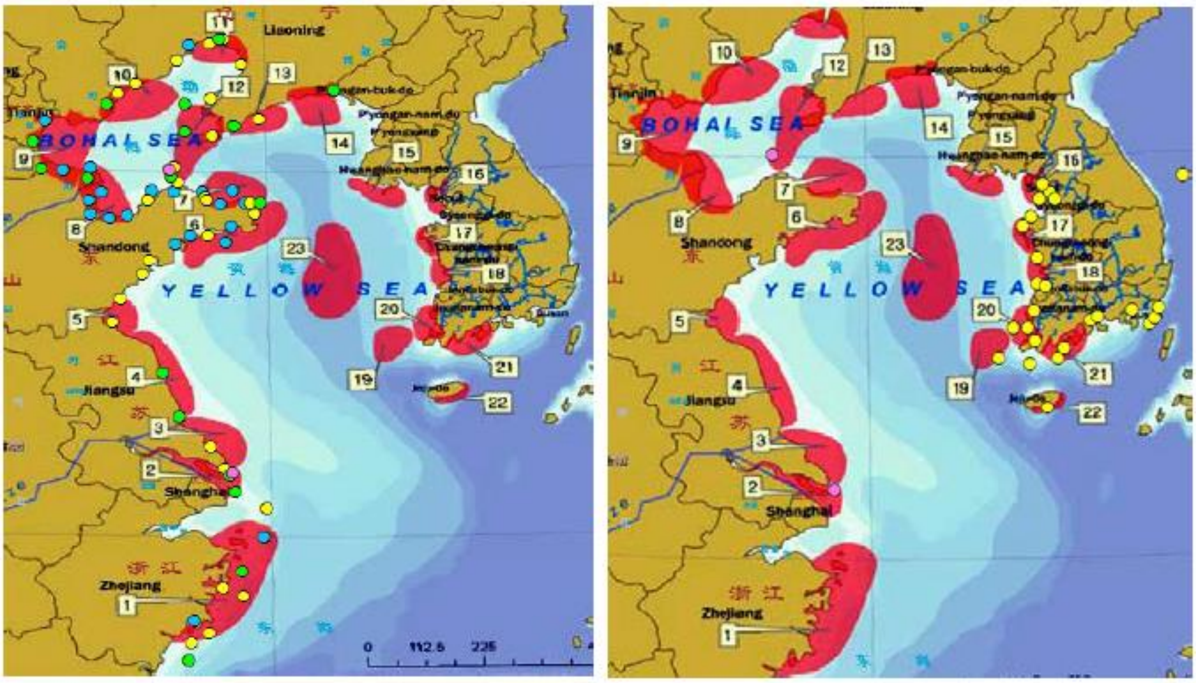


Figure 25. Spatial protection gaps in the YSLME ***(Reproduced from Zhang, YSLME 3rd Science Conference, keynote presentation)***

China has steadily increased the number of MPAs. More critical habitats have been protected in YSLME region. More MPAs have been designated after 2007 in YSLME region, including Bohai Sea. Before 2007, there 17 national level MPAs, with a total area of 1.5 million ha. By the end of 2018, the number increased to 58, and the total area was 2.1 million ha. In 2012, the State Council authorized the National Marine Functional Zoning (2011 – 2020), setting a goal to improve the marine environment with an expansion of marine protected areas. By 2017, there were 31 national-level MPAs and 21 national level Aquatic Germplasm Resources Conservation Zones in the YS (Figure 26, Figure 3.9, C-NSAP, p 58). As of 2017, Korea designated 28 MPAs along the entire Republic of Korea peninsula (Figure 27, Figure 41, K-NSAP, p 131), with a total area 586 km^2. These consisted of protected areas for wetlands (236 km^2), marine ecosystems (259 km^2), and marine organisms (91 km^2).

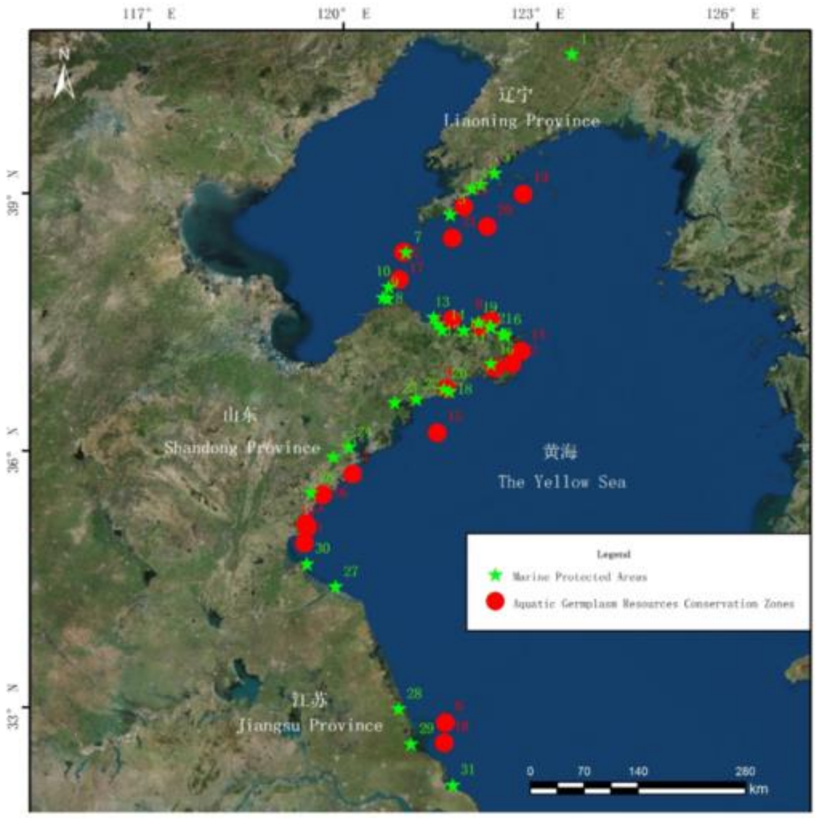


Fig.3.9 the National level MPA and Aquatic Germplasm Resources Conservation Zones in YS.

Figure 26. National level MPA and aquatic Germplasm resources conservation zones in YS ***(from C-NSAP, p 58)***

Figure 41 Designated Marine Protected Areas in Korea (as of 2018)

Figure 27. Designated marine protected areas in Korea (as of 2018) ***(from K-NSAP, p 131)***

Korea has also led efforts to establish a domestic and international networks of MPAs. The Korea Marine Environment Management Corporation has been working to expand the domestic Mudflat Center Network more broadly to a Regional MPA Network. Further expansion of these efforts are anticipated to include the conservation and restoration of MPAs, establishment of a foundation for sustainable use and management of MPAs by strengthening domestic and international networks, and improvement of the brand value of MPAs by raising public awareness of MPAs (K-NSAP, p 132).

2.4.4 Invasive Alien Species

Invasion of alien species is one of the main causes of biodiversity loss. YSLEM Phase II SAP Implementation is addressing invasive species through the control and monitoring of the inflow (Action 11.1) and the prevention of new introductions (Action 11.2) of non-native species (Table 14).

| Table 14. Management Actions Related to Invasive Alien Species.

Action 11.1	Control and monitor the inflow of non-native species.
Action 11.2	Control non-native species efficiently with precautionary approaches.

Invasive species can be introduced inadvertently or intentionally. Marine systems are particularly vulnerable to invasive species released in the ballast water of ships, but also through accidental transportation through other means. According to Bai & Ma (2015), the number of marine invasive species in the YSLME was 120, of which, six species were microbes, 45 species were animals, and 69 were plants (C-NSAP, p 59).

Invasive species can also be introduced intentionally, because of their superior ability to perform some function in designed systems. The rooted wetland plant, *Spartina* was introduced intentionally to China from USA in 1979 for ecological restoration projects. Due to its strong adaptability and high reproduction, it spread extensively along the cost of China, displacing native wetland species, resulting in significant impact on wetland ecosystem health. Studies conducted in the Yanching National Nature Reserve from 2006 to 2015 observed an expansion rate for *Spartina* of 1.35 km^2/year (C-NSAP, p 59 – 60).

Korea has been extensively engaged ballast water management. Their efforts including development of portable devices to detect the presence of microalgae in ballast water; developing water treatment facilities for ballast water, including strategies for exchange and disposal of ballast water; tightening regulatory requirements for reporting ballast water operations; and expanding the infrastructure and support for national research and development for ballast water management. Korea's activities also include conducting an international forum on ballast water and expert training (K-NSAP, p 140 – 147).

Korea's activities to control non-native species with precautionary approaches includes revision of the regulation on and management system for the introduction of the introduction of non-native species, conducting epidemiological and damage studies for non-native species and the creation of an information management system, a project to eliminate harmful marine organisms, and efforts to raise public awareness of and draw attention to the introduction of introduced species (K-NSAP p 147 – 156).

3 YELLOW SEA LIVELIHOODS AND SOCIOECONOMIC IMPACTS

The coastal economies of the Yellow Sea rely on the ecosystem services provided by the Yellow Sea, either directly through the various marine fisheries products, or indirectly through tourism, marine service industries, and other socioeconomic drivers that rely on access to the sea. This section provides an overview of socioeconomic conditions in the Yellow Sea coastal areas of China and Korea at the onset of the YSLME Phase II SAP are described in the overview below (Section 4.1). The observed and anticipated impacts of SAP interventions on livelihoods and socioeconomic conditions in the Yellow Sea region are describe in the following sections of Chapter 4.

3.1 Overview of Socioeconomic Conditions of the Yellow Sea

3.1.1 China

Three provinces form China's coastline on the Yellow Sea: Liaoning in the north, followed southward by Shandong and Jiangsu. They occupy an area of 410,000 km^2, accounting for 4.2% of the total land area of China. In 2016, the total population of this region was about 218 million, accounting for 15.8% of the total population of China. This population density is much higher than average for China. The major coastal cities of the Yellow Sea are Dandong, Dalian, Yantai, Weihai, Qingdao, Rizhao, Lianyungang, Yancheng, and Nantong. About 50 million people living in the coastal cities and counties of the Yellow Sea, of which about half make their living fishing.

The coastal regions of the Yellow Sea in China have developed quickly in recent decades. In 2016, the Gross Domestic Product (GDP) of the three coastal provinces was 16.5 trillion yuan (about USD $2.4 trillion), which was 22% of the GDP of the whole country. Nationwide, Jiansu has the second largest economy in China, followed by Shandong with the third largest economy, and Liaoning with the 14th largest economy.

In 2016, the marine GDP of the coastal regions of the Yellow Sea was 2.54 trillion yuan (about USD $360 million), which was 3.4% of the GDP of the whole country and 36% of the marine GDP of the whole country. The major marine industries are marine fisheries, coastal tourism, the marine salt industry, the marine chemical industry, marine biological pharmaceutical industries, marine shipbuilding, the marine power industry, marine engineering projects, marine transportation, and comprehensive utilization of seawater.

The coastal regions of the Yellow Sea are well developed in industry and agriculture, of which their products play an important role in China. The transportation infrastructure is well developed with ample and well-maintained highways, airports, and harbors. The more than one hundred harbors are a vital economic resource for China, of which Dalian Harbor is the most important in northeast China. Qingdao Harbor is the second largest harbour in terms of freight and ranks third in container transportation in China and 15th worldwide.

3.1.2 Korea

- To be completed.

- Overview of Impacts of Ecosystem Management Interventions on Livelihoods. Note: This section briefly introduces the concepts in the bullet points below. More detail will be provided in Section 4 below for each
  - Reduction in fishing boat numbers - Buy-back of fishing boats and retraining
  - More strict fishing regulations
  - Development of IMTA opportunities

- Investments in land-side infrastructure to improve water quality in YSLME

3.2 Capture Fisheries

- Need to add:
  - How big is the commercial fishery?
  - What are the commercially important fisheries?
  - What is the proportion of large commercial fishing interests versus medium and family-scale fishing.
- C-NSAP
  - Section 2.2.2.1 - Reduction in fishing efforts
- K-NSAP
  - Management Actions 1.1 and 1.2 - Data related to reduction in fishing efforts and changes in commercial fishing regulations
- Results from Marine Economics session at Science Conference in July 2019

3.3 Mariculture

- Anticipated changes in livelihoods associated with improved practices in recirculating mariculture and IMTA.
- Anticipated negative impacts on livelihoods associated with controlling certain mariculture practices determined to be detrimental to ecosystems.
- Also include: Report on the socio-economic implications of the fishing vessel buy-back program scheme.

3.4 Other Impacts

- Impacts to marine industries
  - Changes in regulations on ballast water.
- Land-side impacts
  - Upgrading infrastructure to reduce point sources of nutrients
  - Changing practices for fertilizer application in agricultural lands
  - Socioeconomic impacts of regulatory changes related to reclamation and commercial development in coastal areas.

4 LEGAL AND INSTITUTIONAL FRAMEWORKS

4.1 Legal and Governance Mechanisms

- *Summary of information provided in deleted section below, with reference to an annex listing the governance and regulatory activities presented in the NSAP reports.*
- *Section on Progress on Regional Governance*
- *Section on International Conventions, including the draft table below:*

Convention	Date Ratified		Status
	China	Korea	
Codex alimentarius			
Stockholm Convention			
MARPOL 1973/78			
UNFCCC			
CBK			
UNCLOS			
RAMSAR			
Code of Conduct for Responsible Fisheries			
London Convention			
Others			

4.2 Legislative Actions though SAP Implementation

The SAP has adopted four actions aiming at improving the effectiveness of legal instruments. These actions have been implemented at different level and different extent and are:

1. Implement international and regional treaties and guidelines;
2. Periodic review of the implementation of treaties by each of the participating country;
3. Exchange of information on relevant domestic legislation; and
4. Development of projects to harmonize domestic legislation

With regard to implementing international treaties and guidelines, based on the TDA, four areas have been addressed that need more efforts and attention from countries in the region, including:

1. Ensuring full ratification of the treaties;
2. Strengthening co-ordination between the bilateral Fisheries Agreement between China and ROK in the YSLME Commission Context;
3. Developing regional guidelines in order to incorporate suggested guidelines of the FAO Code of Conduct for Responsible Fisheries into the YSLME Commission's Context; and
4. Developing guidelines on matters not covered in detail by the United Nations Convention on the Law of the Sea, Convention on Biological Diversity and Ramsar Convention.

Implementation of international and regional treaties and guidelines has been greatly improved in both countries. Almost all the international conventions or agreements or treaties that related to marine environment protection and sustainable use of marine resources have been ratified. After the ratification, as a contracting party China has been working to improve national laws, regulations and policies to fulfil the obligations under those conventions. After 20 to 30 years of construction, China has set up a basic legal and regulatory framework for the conservation of the marine environment and sustainable use of living resources, including Marine Environment Protection Law, Fisheries Law, Wild Animal Conservation Law, Marine Island Conservation Law, Regulation on the Management of Nature Reserve, Rule for Wetland Protection; Law on the Administration of Sea Areas; and other related environmental laws. In order to implement the above laws or to regulate the issues which have not been addressed in the current laws, the State Council, administrative departments of central government, local people's congress and local people's government issued about 80 regulations and rules of all levels, which to a large extent enriched the legal system on marine environmental protection. Besides the laws, the Government of China has issued a variety of national policies and plans, and launched a number of projects to protect the marine environment.

Regular dialogues on bilateral fishery agreement have been carried out between China and ROK governments. China-Korea Joint Committee for Fishery held meeting annually to discuss issues appeared in the implementation of the bilateral Fisheries Agreement.

However, none of the regional guidelines have been developed on FAO CCRF or other matters not covered in detail by UNCLOS, CBD, Ramsar Convention and other conventions.

The second action calls for a periodic review of the implementation of treaties by each of the participating country. Many international conventions or treaties require contracting parties to submit periodic review to reflect the implementation status, such as CBD, UNFCCC, Ramsar Convention etc. However, no guidelines have been developed within the YSLME context for periodic review of the implementation of treaties.

The third action, exchanging information on relevant domestic legislation, has been fully implemented, as YSLME Phase II project has organized several projects to exchange information on relevant domestic legislations.

The fourth action is developing projects to harmonize domestic legislation according to the regional standards and guidelines to be developed through YSLME Commission. As no regional standards or guidelines have been developed through YSLME Commission, no projects have been launched to harmonize domestic legislation in order to bring the domestic legislation in line with the regional ones.

4.3 Improving the Effectiveness of SAP Implementation

Three actions can be undertaken to improve the effectiveness of further SAP implementation: Address issues that attract international attention, prioritize regional interventions, and exploit potential synergies in implementing international treaties.

First, consider issues or areas that attract international attention. There are issues or areas that are becoming important global policy issues in recent years, such as climate change, marine debris and micro plastics, or issues or areas that are increasingly receiving political attention at the international level, such as nitrogen and other nutrients, MPA network etc. International conventions, treaties or agreements tried to include these issues or areas within the established framework through Conference of Parties Resolution, strategic plan or guidelines. When revising the management actions of SAP, it is recommended that these issues or areas be taken into consideration under the YSLME context.

Second, actions with a regional feature should be given priority. According to the first SAP and two NSAP assessment reports, it is founded that actions such as develop regional guidelines, regional standards, regional methodologies are not implemented well. For revision of SAP, these actions should be given priority as before, because the actions to develop regional policies and guidelines are the fundamental and most significant part in regional ocean governance. It is the regional policy that demonstrate the irreplaceability and value of regional governance as a separate layer of governance other than the international and national ones.

Third, list synergizing implementation of international conventions, treaties and agreements as a legal action. Many actions have been taken to implement international conventions, treaties and agreements, however many of them have not been taken synergistically. By this way, lots of resources were wasted and the ecosystem-based approach hasn't been used. While renewing the SAP, it is suggested that synergizing implementation of international conventions, treaties and agreements be adopted as a regional legal action to emphasize the inter-relation within different actions.

4.4 Progress on Regional Governance

- Information sources to include:
    - Architecture of the Interim YSLME Commission
    - ToR for A Study on Options for a Regional Ocean Governance Mechanism for the YSLME

4.5 International Conventions

- Conventions
    - Codex alimentarius
    - Stockholm Convention
    - MARPOL 1973/78
    - UNFCCC participation and relevance with YSLME activities
- Need to edit to avoid redundancy with Section 3.2.3 Contaminants.

4.6 Engagement with DPRK

- Information sources to include:
    - Yellow Sea Partnership - DPR Korea with HSF
    - Information from Session 12.1 of ICC-3 conference

5 PRIMARY PROBLEMS AND ROOT CAUSES

The 2007 TDA analysed primary problems in the YSLME, categorized by the four scientific components for which Regional Working Groups (RWGs) were formed. These were fisheries, pollution, ecosystems, and biodiversity (TDA 2007, Section 6). These problem areas were examined more deeply through causal chain analysis (CCA) exercises (TDA 2007, Section 7). For each problem, its fundamental problem, or driver, was identified. From there, the primary cause was determined, followed by intermediate causes, and finally a root cause was listed. Multiple causes may be attributed to problems. For example, the 2007 TDA listed six primary causes and 11 root causes for the problem of Eutrophication and Harmful Algae Blooms.

This detailed analysis of problems and their causes at the TDA level, sets the stage for interventions that can be proposed at the SAP level. The hierarchy of primary, intermediate, and root causes allows for flexibility in the design of interventions. Primary causes, such as, "Sewage discharge into seas and rivers," can be more readily addressed through interventions, but do not address more fundamental causes of problems. Root causes, such as, "Limited influence of environmental constituency on government policies," address the most fundamental drivers of problems, but are difficult (or impossible) to solve through SAP interventions. Nonetheless, identifying root causes is essential for both understanding the ultimate drivers of priority problems, and to set courses to obtain aspirational goals.

The 2008 SAP translated the primary problems and causal chain analysis into a set of nine environmental problems and causes. It is useful to categorize these nine problems in terms of the four RWG disciplinary areas, as both the Phase I and Phase II YSLME projects used the same RWG structure in their operations. The nine primary problems and their corresponding disciplinary area are listed in **Table 15**.

| Table 15. Primary Problems in the YSLME.

Fisheries	1. Fishing effort exceeding ecosystem carrying capacity 2. Mariculture facing unsustainable problems
Pollution	3. Pollution and contaminants
Ecosystem Changes	4. Eutrophication 5. Jellyfish blooms 6. Harmful algae blooms (HABs) 7. Change in ecosystem structure 8. Climate change-related issues
Biodiversity	9. Habitat loss and degradation

The CCA in the 2007 TDA has been re-examined and updated through a process that started with the SAP Workshop conducted at the YSLME 3rd Science Conference in Qingdao, July 2019. Subsequently the RWGs and other stakeholders have reviewed and updated the CCA. These revisions provide the basis for examining the causes associated with the primary problems and for revising management actions in the SAP update. This section addresses the primary problems and their causes, as developed by the YSLME Phase I project, and re-evaluates them based on the findings of the YSLME Phase II project.

5.1 Fisheries

The Regional Group on Fisheries (RWG-F) addressed problems associated with commercial fisheries and mariculture.

5.1.1 Description of the Problem

The situation with regard to capture fisheries at the end of the YSLME Phase I project was dominated with problems of commercial overfishing. The capture production in the Yellow Sea grew at an explosive rate from 400,000 tonnes in 1986 to almost 2.5 million tonnes in 2004. This well exceeded the carrying capacity of the system, with commercial and ecosystem consequences. The composition of catches shifted to lower-value species, and ecosystem structures changed (SAP p 4).

In this same period, the mariculture production in China grew to 13.84 million tonnes in 2005, thereby supplying 73.2% of the world's total demand for farmed marine organisms. The environmental impacts of this growth include increased release of organic wastes, and competition for food resources among cultivated organisms. These factors all increase stress and lower the growth and survival rates of cultured organisms, thus reducing productivity (SAP p 5).

5.1.2 Progress in Addressing the Problem

The Phase II YSLME project addressed capture fisheries and mariculture in a series of separate management actions (Tables 3.1 and 3.2). With regard to capture fisheries, management actions associated with buy-back programs for fishing vessels (Action 1.1) and closure of fishing areas and season (Action 1.2), had immediate and significant positive impact on fisheries in the Yellow Sea. Management actions calling for increased mesh size (Action 2.1) and fish restocking (Action 2.2) also contributed to recovery of the YSLME fisheries. While the recovery of wild fisheries is being observed, continued efforts to decrease fishing pressure and improve capture fishing practices are necessary.

A key vulnerability in mariculture is the growth and transmission of diseases, due to the high density of organisms. Important progress has been made during the Phase II YSLME project on developing early warning diagnosis systems for detecting and responding to disease outbreaks.

However, the mariculture industry itself has not changed significantly during the Phase II YSLME project. Project activities have investigated and promoted Integrated Multi-trophic Aquaculture (IMTA) and improved technology for seawater recirculating aquaculture systems (RASs). These promising advancements may appeal to commercial interests through improved productivity, but ultimately will require regulatory pressures to be implemented at large scales in the YSLME.

5.1.3 Emerging Problems

Emerging problems related to capture fisheries and mariculture include:

- *Hidden risks from lack of assessment of marine ranching to the marine environment as a part of the management actions*
- *Re-employment of displaced fishermen remains top on the agenda of both governments*
- *Increasing impact of extreme climate and heatwave to the mariculture*

5.1.4 Causal Chain Analysis

The updated causal chain analysis for fisheries is provided in Annex 3. Compared with the Causal Chain Analysis from the 2007 TDA, concerns regarding overfishing have been decreased, but vigilance is still necessary for recovery of the wild fishery, particularly species of greatest commercial interest. Intermediate and root causes for declines, or slow recovery, of capture fisheries include insufficient scientific knowledge of fishery stock management and the limits to sustainable natural resource management exploitation. Increased reliance on mariculture has the potential to create greater pollution impacts on the YSLME. The primary causes for unsustainable mariculture practices included over-intensive mariculture development, over-exploitation of natural habitats, and limited and variable natural nutrition supplies for the organisms. The main root causes were, "Coastal development undertaken with limited comprehensive and coherent legislation that provides adequate environmental protection," and "Lack of comprehensive and coherent framework for coastal and marine resource development."

5.1.5 Preliminary Recommendations to Guide SAP

This is a topic for discussion at the ICC-4 meeting.
Potential recommendations can include continued efforts to re-balance the capture fishery through continuation of incentives for fishing fleet reductions and increased incentives for and application of sustainable mariculture practices, such as IMTA.

5.2 Pollution

The 2008 SAP initially identified, pollution and contaminants under the heading, "pollution." In the Phase II YSLME project, the Regional Working Group on Pollution (RWG-P) added marine litter as a pollutant. Other concerns are increases in atmospheric deposition of particulate matter (PM10 and PM2.5) associated with industrial emissions, and emerging contaminants associate with wastewater discharges.

5.2.1 Description of the Problem

Pollutants entering the YSLME have both land-based and marine origins. Land-based pollutants consist primarily of nutrients and pathogens released through agricultural, municipal, and industrial sources, which are either poorly treated or untreated. Marine pollutants can include nutrients and pathogens, but are primarily oil, persistent organic pollutants (PoPs) and other toxic contaminants released from marine vessels. Marine litter, consisting primarily of plastic waste, can have terrestrial and marine origins. In the Yellow Sea, a significant source of marine litter is the decomposition of Styrofoam buoys.

5.2.2 Progress in Addressing the Problem

An important area of progress in the Phase II YSLME project has been to develop coordinated monitoring programmes. Water, sediment, and atmospheric quality monitoring programs have long been extant, but the Phase II project has enabled reliable baseline information to be collected, against which future changes can be evaluated (Actions 4.1 and 7.1). With regard to actions for reducing the quantity of land-based pollutants, both point sources of municipal and industrial waste (Action 5.1) and non-point sources of agricultural pollution (Action 5.2) have been targeted for reduction through facility upgrades, construction of new facilities, and implementation of best practices. Additionally, new regulatory approaches oriented toward limiting the total allowable amounts of pollution discharge from specific regions or water systems is being implemented (Action 5.3).

Marine litter and contaminants are the other major pollutants. Progress in decreasing marine litter have focused on reducing the amount of litter generated (Action 6.1), strengthening capacities to collect and treat marine litter (Action 6.2), and developing information management systems for litter (Action 6.3). Progress toward resolving problems of marine contaminants has been oriented toward complying with international conventions (Actions 4.2 and 4.3).

5.2.3 Emerging Problems

Emerging problems related to pollution include:

- Greater recognition that increased HAB blooms can enrich the YSLME in organic nitrogen.
- Greater recognition of the extent and possible ecosystem damages at all trophic levels caused by micro-plastics in the environment.
- Acidification: data are available in YSFRI on the effects on bivalves, and data from NMEMC.
- PM2.5 and PM10 are suggested by ROK but are considered as factors contributing to silicate.
- Threat of marine plastics greater than originally understood.
- Contaminants of emerging concern (e.g., pharmaceuticals) associated with poorly treated or untreated wastewater.

5.2.4 Causal Chain Analysis

The causal chain analysis for pollution (TDA Table 12, reproduced in Annex 3 of this document.) included issues and concerns that were grouped with Ecosystem Changes in the YSLME Phase II project. The issue of concern relevant to this section was identified as, "Contaminants and their effects (i.e., Pollution)." Within that issue, the fundamental problems and drivers included most of the pollutants covered in this section: pathogen contamination, PoPs, heavy metals, and marine litter. Primary causes include land-based and marine pollution sources, as described previously, but also include more specific sources, such as steel production emissions, the pulp and paper industry, and home heating emissions. Root causes include improper siting of industrial facilities and inadequate enforcement of existing laws and regulations..

Nutrient enrichment was considered as a fundamental problem and driver within another concern, "Eutrophication and Harmful Algal Blooms". This fundamental problem is relevant to the following section, "Ecosystem Changes", but the actual monitoring and control of nutrients is covered here. Primary problems included industrial, municipal, and agricultural sources. Root problems include high density of maricultural facilities, inadequate balance between development and environment, and inefficient application of good agricultural management practices.

5.2.5 Preliminary Recommendations to Guide SAP

This is a topic for discussion at the ICC-4 meeting.

5.3 Ecosystem Changes

The ecosystems of the YSLME responded to the primary drivers of change: nutrient and pollutant loading, which first affects the lowest trophic levels of the ecosystem in a "bottom up" fashion, and commercial fishing pressure, which affects first affects the highest trophic levels of the ecosystem in a "top down" fashion. Therefore, while pollution and fishing are issues and concerns in other areas of this work, they are fundamental drivers or primary causes with respect to ecosystem changes.

5.3.1 Description of the Problem

The main problems addressed are nutrient over-enrichment or imbalance (eutrophication), resulting blooms of harmful algae (HABs) and jellyfish, and overall changes in ecosystem structure. Climate change impacts can affect any of the trophic levels individually, but collectively add to the overall changes in ecosystem structure. Monitoring programs described previously in "Pollution" were used to evaluate nutrient ratios, primarily the elemental ratios of nitrogen to phosphorus and nitrogen to silicate. These ratios can indicate over-enrichment of nitrogen, which can lead to a dominance in undesirable algae over diatoms. Decreases in the dominance of diatoms can lead to harmful algae blooms and lead to changes in ecosystem structure that favour lower-valued fish species.

Blooms of harmful algae and jellyfish are themselves a nuisance. In the case of HABs, the release of toxins can result. In the case of jellyfish, this can result in human health risks through stings and consequently impact tourism. A direct impact of climate change on ecosystems is the shift in the location and abundance of temperature-sensitive species as a result of warming.

5.3.2 Progress in Addressing the Problem

The Phase II YSLME project has established baseline monitoring for nutrient ratios; the presence, duration, and extent of nuisance blooms; and measures of climate change. These data are being used in predictive modelling studies to anticipate changes in ecosystem structure. Examples of the results of these efforts include observed decreases in the ratios of nitrogen to phosphorus and nitrogen to silicate inthe Korean waters of the YSLME. This is an early indication that diatoms may be able to compete for dominance in that ecosystem. Another example is a modelling student to understand the impact of climate warming on the distribution of the economically important Japanese anchovy. Preliminary results indicate a northward shift in the abundance of this species.

5.3.3 Emerging Problems

- Greater recognition of the extent of indirect and direct climate change impacts, including changing terrestrial erosion patterns and sea-level change impacts on coastal zones (mudflats and wetlands).
- Sargassium spp outbreaks and impact to tourism in ROK and mariculture in northern coast of Jiangsu
- Declining frequency of HABs, with increased proportion of toxic species; widespread macroalgae and jellyfish blooms.

5.3.4 Causal Chain Analysis

Issues and concerns related to ecosystem changes were addressed in the causal chain analyses for Pollution Problems (Annex 3, Table 12, Eutrophication and Harmful Algae Blooms and Toxic Algae Blooms) and Ecosystem Problems (Annex 3, Table 13, Changes in Biomass or Abundance, and Species Composition; Increased Frequency of HABs; and Loss of Benthic Habitat in Coastal Areas); and Biodiversity Problems (Annex 3, Table 15, Changes in Species Abundance and Diversity).

With regard to Eutrophication and HABs, primary problems, as discussed previously, were related to nutrient releases from point and non-point sources and root causes were related to inadequate infrastructure, regulations and policies. With regard to changes in species composition and biomass, primary causes generally related to changes in predator / prey interactions, changes in nutrient ratios, and removal of top predators through overfishing. Root causes related to inadequate, or poor enforcement of, regulations related to nutrient releases and fisheries.

Specific to climate change, one of the primary causes was observed to be changes in plankton species structure. Intermediate causes were regional and global climate change. The root cause related to implementation of the United Nations Framework Convention on Climate Change (UNFCCC) and observed that both China and Korea are parties to the Kyoto Protocol.

5.3.5 Preliminary Recommendations to Guide SAP

This is a topic for discussion at the ICC-4 meeting.

5.4 Biodiversity

Preserving coastal habitats is at the core of protecting biodiversity in the YSLME. The 2008 SAP reports that, "Habitat has been lost at a staggering rate, with almost 40% of coastal wetlands being converted to other uses (SAP p 5). China's moratorium on reclamation and regional efforts to expand MPAs are improving the habitats that can support increases in biodiversity.

5.4.1 Description of the Problem

Biodiversity can be threatened in the YSLME through the destruction or degradation of habitats and through the introduction of invasive alien species. Coastal wetlands and mudflats are important habitats for shellfish fisheries and culture, and many of the commercially important fish species use these areas as nursery or feeding grounds at some stage in their life cycle. Additionally, many endangered bird species depend on these coastal areas as feeding and breeding grounds on the migration routes. In addition, wetlands perform important biogeochemical functions, such as sediment retention, carbon sequestration, nutrient cycling, prevention of saltwater intrusion, and coastline stabilization (SAP p 5).

Invasive alien species create problems in both coastal and open-water areas. The introduction of non-native wetland plants, notably *Spartina*, has resulted in the loss of abundance and diversity of native species of wetland plants. The introduction of non-native planktonic species through uncontrolled releases of ballast water has threatened YSLME ecosystems with imbalances in ecosystem structure.

5.4.2 Progress in Addressing the Problem

Activities to protect biodiversity in the Phase II YSLME project can be placed in the categories of coastal wetlands and reclamation, priority threatened and endangered migratory species, marine protected areas, and invasive alien species. Efforts to protect coastal habitats and the biodiversity they support include regulatory controls on development in coastal zones and establishment of new marine protected areas. Activities to prevent or control the spread of invasive alien species have been targeted to developing better technologies to detect planktonic invasive species and to better manage ballast water.

5.4.3 Emerging Problems

Two key emerging problems have been recognized: alterations in habitats for the spotted seal and critical vulnerability of migratory waterbirds due to a lack of MPAs.

The spotted seal (*Phoca largha*) inhabits the ice and waters of North Pacific Ocean and adjacent seas, and Liaodong Bay in China is the southern-most of the eight putative breeding ground .The spotted seal is a national second-level protected wild animal. It is the only pinniped marine mammal that can breed in China's waters. It is an important flagship species for aquatic wildlife protection and has important ecological, cultural and social values. Spotted seals are mainly distributed in the Bohai Sea and the Yellow Sea. For protecting spotted seal, the governments of China and Korea have established MPAs in Yellow Sea and Bohai Sea. Meanwhile, spotted seal has high mobility with seasonal migratory in the distribution region. Many countries are located along its migratory route: China, ROK, Japan, DPRK, and Russia. The protection status of spotted seal may be different in these countries. To strengthen the protection of spotted seals, marine protected areas network should be established in their main habitats to form a complete marine protection network system.

The Yellow Sea coastal area is an important stop for migratory waterbirds on the East Asian-Australian flyway. Many important wetlands that constitute the stopovers for these birds are irreplaceable, and coastal development and marine engineering encroach many intertidal zones, especially the high-tide zone. Shorebirds ' main foraging areas are concentrated in the mid-tide and low-tide zones. When the tide rises, the shorebirds fly to the high tide zone, which provides safe and undisturbed areas. The absence of these high-tide zones will force shorebirds to fly further afield near ponds or other human structures, and will have to face more threats. Restoring or manually building some high tide zones for bird resting in the area can mitigate the impact of habitat loss on endangered shorebirds.

5.4.4 Causal Chain Analysis

The causal chain analysis for Biodiversity Problems (Annex III, Table 15) identifies the following issues and concerns: habitat loss and degradation, and changes in species abundance and diversity. Within those, the primary causes were loss of coastal habitat, habitat degradation, declines in numbers of key species, and introduction of alien species. The root cause for nearly every primary problem related to uncontrolled or poorly controlled development, or a root cause otherwise related to inadequate regulatory and policy frameworks. The primary problem related to introduction of alien species identifies as its root cause, limited implementation of the Ballast Water Convention.

5.4.5 Preliminary Recommendations to Guide SAP

(1) Carry out general survey of wetland resources, and rescue natural rivers such as river beaches and coastal intertidal zones.
(2) Carry out ecological protection and restoration of degraded wetlands.Increase the intensity of returning farmland to wetlands, returning fisheries to wetland, and mudflat culture ponds within the ecological red line must strictly implement the returning fishing to wetland regulation.
(3) According to the characteristics of different coastal wetlands, the suitable wetland plant species should be planted according to local conditions to enhance the stability of wetland ecosystems

This is a topic for further discussion at the ICC-4 meeting.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This TDA Update reflects new perspectives on the transboundary YSLME. These perspectives have been shaped by new scientific data collected in the YSLME; from the impacts of governance, legislative, and regulatory change put in place since 2007, and from changes in our awareness of the impacts of climate change and emerging pollutants. The activities of the YSLME Phase II project have been responsible for some of the developments that led to these new perspectives.

The key outcomes of the TDA Update process were the following:

1. Provide a summary of the state of the YSLME, with regard to fisheries, pollution, ecosystem changes, and biodiversity.
2. Verify that the nine priority problems (Table 15) identified in the 2007 TDA remain valid and to determine whether or not new priority problems have emerged.
3. Develop a set of primary, underlying, and root causes for these problems through a Causal Chain Analysis (CCA) exercise.
4. Identify any emerging problems or concerns in the YSLME.

Through regional validation meetings and deliberations among RWGs and national stakeholders, it was determined that the nine priority problems remain valid and that no additional primary problems need to be added. An updated causal change analysis revealed that some of the issues, concerns, and primary drivers associated with primary problems have changed since 2007. The updated CCA also reflects changes in our understanding of primary, intermediate, and root causes for these concerns. Underlying and root causes often relate to governance, legislative, and regulatory limitations. Progress with governance and regulatory frameworks has addressed some of these problems. New concerns have also emerged and have been included in the CCA. These include emerging concerns of climate change, micro-plastics, and the deposition of atmospheric pollution.

Emerging problems have also been identified in the updated TDA. These include:

- Fisheries
  - Lack of assessment of the impacts of marine ranching on the YSLME
  - Re-employment of displaced fishermen
  - Increasing impacts of climate change on mariculture
- Pollution
  - Extent of micro-plastic pollution at all trophic levels.
  - Acidification of marine waters due to climate change.
  - Atmospheric deposition of particulate matter in the YSLME
- Ecosystems
  - Direct and indirect effects of climate change on ecosystems
  - Changes in the patterns and distribution of harmful algae blooms
- Biodiversity
  - Increased migration of spotted seal away from the Bohai Sea and YSLME
  - Need to expand marine protected areas to protect threatened and endangered transboundary species

The data and insights collected in the updated TDA will be directly applied to the process of updating the YSLME SAP. Targets and management actions will be reviewed based on the material gathered in Section 5 (Priority Problems and Root Causes) of this document and the CCA.

6.2 Recommendations for SAP Update

- Identify any recommendations for changes in Management Goals / Targets that need revising.
- Identify specific or general changes, additions, or deletions that should be made to Management Actions.

6.3 Recommendations for Next Project Phases

- Identify any technical (rather than policy) considerations that should be made in future activities. For example, how climate change impacts should be handled.

7 REFERENCES

C-NSAP: UNDP/GEF, 2019. Status Report of the Implementation of the National Strategic Action Plan (NSAP) for the Yellow Sea Large Marine Ecosystem of the People's Republic of China.

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SAP: UNDP/GEF, 2009. Strategic Action Programme (SAP) for the Yellow Sea Large Marine Ecosystem.

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Annexes

Annex 1. Annotated List of Information Sources

To be completed.

Annex 2. National Strategic Action Plan (NSAP) Reports from China and Korea

To be included as a "virtual" annex – link to download page.

Annex 3. Causal Chain Analyses, 2019 Update