



# The 2023 IUCN Situation Analysis on Ecosystems of the Yellow Sea with Particular Reference to Intertidal and Associated Coastal Habitats



The 2023 IUCN Situation Analysis on Ecosystems of the Yellow Sea with Particular Reference to Intertidal and Associated Coastal Habitats



Ministry of Oceans  
and Fisheries



# The 2023 IUCN Situation Analysis on Ecosystems of the Yellow Sea with Particular Reference to Intertidal and Associated Coastal Habitats

## Disclaimers

The views expressed in this publication do not necessarily reflect those of IUCN or other participating organisations. The contents of this publication are solely the responsibility of the authors and should not be interpreted as reflecting the views of any of the individuals or organizations that contributed to the publication or any of its elements. The recommendations are without prejudice whatsoever to either the decision of any State Party to consider nominations on its territory, whether mentioned or not mentioned in this volume, or to the potential evaluation of IUCN's World Heritage Panel (or of the equivalent body in ICOMOS) regarding any future nomination of any property for World Heritage status.

The designation of geographical entities in this report, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of IUCN or its partners.

The views expressed in this publication do not necessarily reflect those of IUCN or its partners.

Published by: IUCN Asia Regional Office (ARO), Bangkok, Thailand

Copyright: © 2023 IUCN, International Union for Conservation of Nature

Reproduction of this publication for educational or other non-commercial purposes is authorised without prior written permission from the copyright holder provided the source is fully acknowledged.

Reproduction of this publication for resale or other commercial purposes is prohibited without prior written permission of the copyright holder.

Citation: IUCN (2023). *The 2023 IUCN Situation analysis on ecosystems of the Yellow Sea with particular reference to intertidal and associated coastal habitats*. Bangkok, Thailand: IUCN.

Lead authors: John MacKinnon, David Melville, Nicholas Murray, Mike Crosby, Nicola Crockford and Raphael Glemet.

Cover photo: Coastal development and a flock of shorebirds on the tidal flat of Shuangtai Hekou National Nature Reserve, China © Zhang Ming

Back cover photo: Mundok Wetland Reserve, DPR Korea © Vivian Fu  
Getbol, Korean Tidal Flats World Heritage Site, Suncheon Bay, Republic of Korea © World Heritage Promotion Team of Korean Tidal Flat

Layout by: IUCN Asia Regional Office

Available from: IUCN (International Union for Conservation of Nature), Asia Regional Office,  
63 Sukhumvit Soi 39, Klongtan – Nua, Wattana  
10110 Bangkok, Thailand  
Tel +66 2 662 4029/Fax +66 2 662 4387  
Email address: [asia@iucn.org](mailto:asia@iucn.org)  
[www.iucn.org/resources/publications](http://www.iucn.org/resources/publications)

## CONTENTS

Acronyms .....	viii
List of figures .....	ix
List of tables .....	x
List of case studies .....	x
Acknowledgements .....	xi
Executive summary .....	1
1.1 The state of the Yellow Sea .....	1
1.2 Important measures taken .....	3
1.3 Time to act.....	5
2 Background.....	5
3 Review methodology.....	7
4 Importance and values of Yellow Sea habitats.....	8
4.1 Terrestrial zone (IUCN Terrestrial and Freshwater Realms) .....	8
4.2 Intensive land-use systems biome .....	9
4.3 Intertidal zone (IUCN Coastal Realm – Rocky, Sandy and Muddy shoreline biomes) .....	9
4.4 Deeper marine sections (IUCN marine shelf and anthropogenic structures biomes) .....	11
5 Drivers and threats to the health of the Yellow Sea.....	11
5.1 Threats causing habitat loss/degradation.....	15
5.1.1 Changes in the extent and distribution of coastal ecosystems .....	15
5.1.2 Historical tidal flat losses (1950s – 2000s) .....	16
5.1.3 Recent tidal flat losses (2000-2019).....	18
5.1.4 Land claim .....	19
5.1.5 Reduced river discharge .....	25
5.1.6 Other coastal developments .....	27
5.1.7 Renewable energy farms and other coastal development.....	28
5.2 Over-exploitation .....	30
5.2.1 Overfishing .....	30
5.2.2 Over-harvesting of intertidal mudflats.....	32
5.2.3 Mariculture and other aquaculture.....	33
5.3 Pollution.....	34
5.3.1 Plastic waste.....	34

5.3.2	Eutrophication and algal blooms .....	35
5.3.3	Oil discharge from ships and pipelines.....	37
5.3.4	Toxic chemicals (DDT, PCB and PAH) .....	38
5.4	Invasive alien species.....	39
5.4.1	Spartina cordgrass.....	40
5.4.2	Alien fishery species entering YSE .....	41
5.5	Climate change.....	42
5.5.1	Storm activity .....	43
5.5.2	Sea pH.....	43
5.5.3	Sea level.....	44
5.6	Zoonotic diseases and other threats .....	45
6	Trends in key species .....	46
6.1	Birds .....	47
6.2	Fish .....	49
6.3	Marine mammals .....	50
6.4	Invertebrates.....	51
6.5	Other species of interest.....	55
7	Recent improvements in the protection, conservation management and restoration of the intertidal ecosystems of the Yellow Sea .....	55
7.1	Coastal governance and policy.....	56
7.1.1	International policy and governance.....	56
7.1.2	National Governance and policy .....	57
7.2	Protected area expansion.....	61
7.2.1	Expansion of EAAFP Flyway Network Sites Network.....	64
7.2.2	Progress in relation to the World Heritage Convention.....	64
7.3	Capacity building .....	71
7.4	Growing awareness and attitudes.....	71
8	Future opportunities for enhancing the protection, conservation management and restoration of the intertidal ecosystems of the Yellow Sea.....	77
8.1	Review of main threats, drivers, impacts and proposed mitigation measures.....	79
8.2	Proposed protection, conservation management and restoration strategies .....	86
8.2.1	Governance opportunities .....	86
8.2.2	Policy and planning opportunities.....	88
8.2.3	Site protection.....	88

8.2.4	Site management.....	90
8.2.5	Restoration .....	91
8.2.6	Strengthening data availability .....	93
8.2.7	Capacity building .....	94
9	Conclusion .....	95
10	References .....	98
11	Appendices .....	123

## ACRONYMS

<b>Acronym</b>	<b>Full name</b>
ADB	Asian Development Bank
CBD	Convention on Biological Diversity
CEPA	Communication, Capacity Building, Education, Participation and Awareness
CMS	Convention on Migratory Species
COS	China Ornithological Society
DDT	Dichlorodiphenyltrichloroethane
DPRK	Democratic People's Republic of Korea
EAAF	East Asian-Australasian Flyway
EAAFP	East Asian-Australasian Flyway Partnership
EIA	Environmental Impact Assessment
GEF	Global Environmental Facility
IBA	Important Bird and Biodiversity Area
ICF	International Crane Foundation
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
KOEM	Korea Marine Environment Management Corporation (in ROK)
MNR	Ministry of Natural Resources (in PRC)
MOF	Ministry of Oceans and Fisheries (in ROK)
MoLEP	Ministry of Lands and Environmental Protection (in DPRK)
NBSAP	National Biodiversity Strategy and Action Plan
NGO	Non-Governmental Organization
NR	Nature Reserve
NNR	National Nature Reserve
OECD	Organisation for Economic Co-operation and Development
PA	Protected Area
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyl
POP	Persistent Organic Pollutant
PRC	People's Republic of China
RFI	Regional Flyway Initiative
ROK	Republic of Korea
RRC-EA	Ramsar Regional Center-East Asia
RSPB	Royal Society for Protection of Birds
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
US\$	United States Dollar
WCF	World Coastal Forum
WH	World Heritage
WWF	World Wide Fund for Nature
WWT	Wildfowl & Wetlands Trust
YSE	Yellow Sea Ecosystem
YSLME	Yellow Sea Large Marine Ecosystem
YSWG	Yellow Sea Working Group



## LIST OF FIGURES

Figure 1 Bathymetry and distribution of surface sediments in the Yellow Sea (Koh & Khim 2014). .....	7
Figure 2 Main currents in Yellow Sea (Ma et al. 2019a). .....	7
Figure 3 Schematic diagram of the community evolution on mud flat habitat (Cultural Heritage Administration, Republic of Korea 2019). .....	10
Figure 4 Schematic diagram of community evolution on sand bar habitat (Cultural Heritage Administration, Republic of Korea 2019). .....	10
Figure 5 Boundary of Haizhouwan National Marine Park (Li et al. 2014). .....	13
Figure 6 Aerial view of Blue Bay land claim project, showing the nearly completed seawall © Dihai Chen .....	14
Figure 7 Change in tidal flats in the Yellow Sea between the 1950s and the 2000s mapped at a 5-km grid resolution. Net change between the two time periods is shown on a color ramp from blue (total gain) to red (total loss) (Murray et al. 2014). .....	17
Figure 8 Extent of tidal flats in relation to the cumulative area of land claims in the Yellow Sea since the 1980s (Yim et al. 2018). .....	18
Figure 9 Net loss of tidal wetlands in the Yellow Sea per 3-year analysis period from–2004 - 2019 (Data from www.globalintertidalchange.org). .....	19
Figure 10 Losses of tidal wetlands at four case study sites addressed in subsequent sections. Case study sites are (A) Lianyungang – Haizhou Bay, (B) Yancheng Coast, (C) Yalu River Estuary, (D) Saemangeum Reclamation Project. (Data from www.global intertidalchange.org) .....	21
Figure 11 Saemangeum, in 1984 and in 2020. © 2021 Google, Mountain View, USA .....	25
Figure 12 Declines of sediment outflow from the Yellow River (A) and Yangtze River (B) (Murray et al. 2015 Data sourced from Yang et al. (2005) and Wang et al. (2010)). .....	27
Figure 13 Future trends of coastal land claim intensity of port clusters in the Bohai Sea. The port land claim will continue to expand, however different ports have different land claim intensity (Zhu et al. 2021). .....	28
Figure 14 Rudong, Jiangsu offshore wind farm. © Wu Zhenhua .....	29
Figure 15 Changes in fish species composition in the Yellow Sea (Redrawn from Zhang 2007). .....	31
Figure 16 Traditional cockle harvesting of mudflats in ROK. © World Heritage Promotion Team of Korean Tidal Flats .....	33
Figure 17 Rise in aquaculture production in PRC (Xiao et al. 2017. Data from China Fishery Statistical Yearbook from 1979 to 2015). .....	34
Figure 18 Variation in the distribution and coverage areas of the <i>Ulva prolifera</i> green tides from 2007 to 2018 (Zhang et al. 2015). .....	36
Figure 19 Northward drifting of Sargassum in 2015 and 2017 (Qi et al. 2017). .....	37
Figure 20 Areas affected by typhoons, diseases, and pollution incidents in the (a) Bohai Sea, (b) Yellow Sea, and the proportion of each disaster category in the (c) Bohai Sea and (d) Yellow Sea in a given year from 2008 to 2018. (Zhang et al. 2022). .....	46
Figure 21 Proportion of globally Threatened and Near Threatened waterbird species by flyway (MacKinnon et al 2012) .....	48
Figure 22 Taxa are ordered from highest to lowest Yellow Sea reliance, the proportion of the flyway population that stages on Yellow Sea tidal mudflats to refuel for long-distance migrations. (Studds et al. 2017) .....	49
Figure 23 Artificial seal resting platforms in ROK © Park Jeong Woon 2019 .....	51
Figure 24 Vegetation types of Yalujiang NNR. © WH Nomination Dossier Phase 2 .....	52
Figure 25 (a) <i>Potamocorbula laevis</i> (b) Distributing <i>P. laevis</i> from a fishing boat at high tide (Source: Shoudong Zhang). .....	54
Figure 26 Marine and coastal protected areas and zones of Jiangsu province, PRC. (Jiangsu Marine and Fisheries Bureau 2016). .....	59
Figure 27 Marine Environment Protection Governance of ROK (modified from Nam 2017). .....	60

Figure 28 Change in number and area of national nature reserves (NNRs) along the Yellow Sea coast in PRC (Ma et al. 2018) .....	63
Figure 29 Map of the Migratory Bird Sanctuaries along the Coast of the Yellow Sea-Bohai Gulf of China (phase I) in Jiangsu Province.....	66
Figure 30 Topographic map of the Getbol, Korean Tidal Flats Phase 1 World Heritage Sites. © World Heritage Promotion Team of Korean Tidal Flat .....	67
Figure 31 Representative scenery of the inner rocky island-type (archipelagic) mud flat in the Getbol, Korean Tidal Flats World Heritage property at Shinan Getbol © World Heritage Promotion Team of Korean Tidal Flat.....	68
Figure 32 Zonation Map of Gochang Getbol © World Heritage Promotion Team of Korean Tidal Flat .....	69
Figure 33 Gochang Getbol © World Heritage Promotion Team of Korean Tidal Flat .....	70
Figure 34 2020 Yellow & Bohai Sea Coastal Wetlands Symposium held in Yellow Sea National Forest Park © Yellow Sea Wetland Institute.....	73
Figure 35 The 2019 Shinan International Symposium. © Shinan County .....	74
Figure 36 Black-faced Spoonbill Birthday Party at Namdong Reservoir, ROK. © EAAFP .....	76
Figure 37 Swan Goose Festival in Mundok Bird Reserve, DPRK. © Vivian Fu/ EAAFP .....	77
Figure 38 Far Eastern Curlew (EN) resting on a floating roost. © D. R. Weller.....	93

## LIST OF TABLES

Table 1 Estimates of the historical change of tidal flat extent in the Yellow Sea, by country, between the 1950s and 2000s.....	16
Table 2 Recent estimates of the extent of tidal flats and reclaimed land in the Yellow Sea. The cumulative area of reclaimed land exceeded the estimated extent of tidal flats in the last decade of the 20 <sup>th</sup> century. Note that decadal estimates cover a 10-year period. (Yim et al. 2018).....	17
Table 3 Losses and gains of tidal wetlands (tidal flats and saltmarshes) in the Yellow Sea from 1999-2019 (Data from <a href="http://www.globalintertidalchange.org">www.globalintertidalchange.org</a> ).....	19
Table 4 Coastal land claim in the Yellow Sea from 1980 to 2020; accumulated area since 1980 in parenthesis. (Yim et al. 2018).....	21
Table 5 Details of components of the Getbol, Korean Tidal Flats Phase I World Heritage Site.....	68

## LIST OF CASE STUDIES

Case Study 1 Lianyungang/Haizhou Bay .....	12
Case Study 2 Yalu River Estuary National Nature Reserve .....	52
Case Study 3 Serial World Heritage property in PRC .....	65
Case Study 4 Serial World Heritage property in ROK .....	66
Case Study 5 Gochang Getbol .....	69
Case Study 6 Mundok Swan Goose Festival.....	76

## ACKNOWLEDGEMENTS

The development of this publication was a collaborative process. The lead authors were John MacKinnon, David Melville, Nicholas Murray, Mike Crosby, Nial Moores, Nicola Crockford and Raphael Glemet, however, the publication benefitted from the inputs from a wide range of experts.

Special acknowledgement to the Ministry of Oceans and Fisheries of the Republic of Korea for supporting the development of this Situation Analysis. The authors would also like to thank the many individuals who have freely given data, advice and recommendations throughout this review. Among those deserving special mention are Kyong-O Moon, Jiyoung Jang, Ho Myoung, Gusung Lee, Jungho Nam, Seungsoo Chun, So Hyun Park, Kathryn Bimson, Taej Mundkur, Doug Watkins, Hyeseon Do, Vivian Fu, Ding Li-Yong, Nial Moores, Tim Badman, Clemens Kupper, Suh Seung Oh, Thomas Lambert, Vinayagan Dharmarajah, Spike Millington, Christoph and Gill Zöckler, Terry Townshend, Lei Guangchun, Li Jiao, Simba Chan, Lu Hefen and Ginnie Chan. We must also acknowledge and thank the many dozens of birders whose records have been used in updating the databases on which our knowledge is based.

## EXECUTIVE SUMMARY

The Yellow Sea Ecosystem (YSE) of intertidal wetlands, associated habitats and the biodiversity that depend on them is among the ecological wonders of the world. Essential ecosystem services such as fisheries provision, tourism, disaster risk reduction and blue carbon storage have long supported the socio-economic development of communities that fringe the coastlines of the Yellow Sea and Bohai Gulf region. However, immense degradation of natural ecosystems across the Yellow Sea region, which encompasses the coastal environments of People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK) and the Republic of Korea (ROK), has occurred over the last 70 years.

In 2012, the *IUCN Situation Analysis on East and Southeast Asian intertidal habitats, with particular reference to the Yellow Sea (including the Bohai Sea)*<sup>1</sup> synthesised information on the alarming decline and degradation of intertidal ecosystems across East and South East Asia. Since 2012, recognition of the outstanding biological and socio-economic value of this region has continued to grow, and vigorous research activity has yielded a stronger understanding of the vital ecosystem services that natural ecosystems in the Yellow Sea provide. Importantly, new efforts have been made over the last 10 years to reduce the rate of coastal development, protect remaining natural habitats and restore degraded habitats, yet additional drivers of degradation have continued to emerge.

This report provides a review of the status of the Yellow Sea Ecosystem since the publication of the previous *Situation Analysis* ten years ago. This report aims to:

1. Synthesise recent information about the status of the Yellow Sea, its natural ecosystems and the biodiversity that relies on them;
2. Summarise what is known about the social and ecological value of the ecosystems of the Yellow Sea;
3. Document the latest information on historically well-known drivers of degradation such as coastal reclamation, and identify emerging threats to the integrity of the system;
4. Summarise ecosystem governance across the region, including recent changes and how they vary across the three countries that directly manage the Yellow Sea Ecosystem;
5. Provide guidance about the strategies required to reduce degradation of one of the most ecologically important coastal ecosystems in the world.

### 1.1 The state of the Yellow Sea

The Yellow Sea is fringed by more than 7,000 km of coastline that spans three countries: People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK) and the Republic of Korea (ROK). Decades of intensive coastal development and a rapid increase

---

<sup>1</sup> Mackinnon et al 2012

in human population along the coastline have led to widespread loss and degradation of the natural ecosystems of the Yellow Sea.

Analyses of satellite imagery archives have confirmed the rapid losses of coastal habitats around the region over a period of more than 70 years. Satellite data suggest that the extent of reclaimed land around the Yellow Sea coastline, which has occurred primarily in areas that were formerly intertidal mudflat, now exceeds the extent of remaining intertidal mudflat habitats across the region.

Importantly, two recent studies have suggested a slowing of the rate of loss of Yellow Sea intertidal ecosystems since a peak around 2013. Despite a slowing in the region-wide rate of loss, widespread losses are still occurring and there are some areas where large-scale reclamations continue to negatively impact the Yellow Sea coastal ecosystems. In particular, satellite analyses and an analysis of planned reclamation activities indicate a rapid recent increase of coastal land claims in DPRK.

As the coast has transformed from a natural to an anthropogenic coastline, fishery catches in the Yellow Sea have subsequently declined by an estimated 40% over a 12-year period.

Similarly, international population monitoring of globally threatened or near-threatened migratory waterbird species that depend on the Yellow Sea intertidal wetlands as migratory stopovers and for wintering and breeding, indicate that populations continue to decline in 81% of monitored species.<sup>2</sup> The population declines of migratory shorebirds have been quantitatively linked to their reliance on remaining Yellow Sea habitats, suggesting that global-scale declines in migratory birds are being driven by widespread degradation and loss of habitats in the Yellow Sea migratory bottleneck.

Unfortunately, the number and severity of environmental threats in the region continue to grow, with recent published studies showing that the pollution levels in the Yellow Sea are alarmingly high (Box 1).

---

<sup>2</sup> Studds et al. 2017

## Box 1 Indicators of the state of the Yellow Sea Ecosystem (2012-2022)

- Of 34 populations of globally threatened and near threatened bird species, 14 (41%) are declining, only 5 are increasing and the rest are stable or uncertain;<sup>3</sup>
- These declines have been clearly demonstrated to be due to habitat loss and degradation in the Yellow Sea coastal ecosystem;
- Region-wide fishery catches have declined by an estimated 40% since 2012.
- The number of people living in the low-elevation coastal zone has increased by approximately 50 million people
- The area of coastal land claims (reclamations) developed over the last 40 years around the Yellow Sea coastline is estimated to be between 9,700-10,500km<sup>2</sup>, which now exceeds the most recent estimate of the area of remaining tidal flats in the region (6,668 km<sup>2</sup>).
- Satellite analyses suggest that the rate of loss of tidal wetlands has slowed since 2013, but is still negative, indicating intertidal wetland loss is continuing.
- The area covered by the invasive alien *Spartina* cordgrass continues to expand in all Yellow Sea countries placing both natural habitats and human livelihoods at risk.
- Algal blooms stemming from eutrophication, increased temperatures and unsustainable mariculture practices are now a serious hazard to the ecosystem.
- Levels of pollutants in the Sea are high.
- Declining inflow of silt is affecting natural intertidal geomorphological processes, including coastal erosion, one of the factors leading to the Yellow Sea to be assessed as 'endangered' under IUCN's habitat criteria.
- Climate change is already having negative impacts in terms of sea temperature altering species distribution patterns, rising sea levels, increased frequency of destructive typhoons and coastal erosion.
- A gap analysis shows that many sites used by threatened and near threatened migratory bird species and other taxa, remain unprotected.

### 1.2 Important measures taken

Over the last ten years, new efforts to reduce environmentally damaging activities have been undertaken across the region (Box 2). Both PRC and ROK have ordered halts to new coastal land claims and, in both DPRK and ROK, the area of wetlands under protection has increased. Two World Heritage (WH) nominations in PRC and ROK have been made to recognise key areas for migratory shorebirds and other waterbirds, especially during staging, and the sites' exceptional importance for the conservation of the world's migratory birds.<sup>4</sup> In addition, countries have made important changes to their environmental plans, policies and laws, which is expected to have a positive impact on the integrity of natural ecosystems in the region.

Community support for coastal wetland conservation and wise-use appears to have increased over the last decade. There has been a substantial increase in the number of volunteer groups and NGOs helping to monitor the migrations of shorebirds and other waterbirds, as well as

---

<sup>3</sup> Appendix 1

<sup>4</sup> World Heritage Committee 2019

increased media coverage and special events,<sup>5</sup> demonstrating enhanced awareness among coastal communities.

Additionally, major projects have been initiated by the United Nations Development Programme (UNDP) under the Global Environmental Facility (GEF), and by the Asian Development Bank (ADB).

### **Box 2 Headline conservation measures over the last decade**

- In 2018, DPRK became a Party to the Ramsar Convention and joined the East Asian-Australasian Flyway Partnership (EAAFP), declaring Mundok Migratory Bird Reserve a Ramsar Site and a Flyway Network Site.
- In 2018 PRC and in 2016 ROK ordered a halt to major coastal land claims, with ROK having stopped new major coastal land claims since 1998.
- ROK and DPRK have both increased the area of wetland protected areas around the Yellow Sea.
- ROK and PRC have succeeded in achieving inscription of Phase I serial WH properties for migratory waterbirds and are now proceeding with Phase II nominations. DPRK has initiated a project to update their Tentative List for WH, which was approved by UNESCO's International Assistance Panel in 2023 and will be supported by the World Heritage Fund.
- There has been a significant increase in the number of volunteer groups and NGOs monitoring the migrations of shorebirds and other waterbirds.
- UNDP has published the Transboundary Diagnostic Analysis for the Yellow Sea Large Marine Ecosystem (2020).
- IUCN has established a Working Group for the Conservation of the Yellow/West Sea Intertidal and Associated Coastal Wetlands since 2018, whilst EAAFP has established a Yellow Sea Ecoregion Task Force.
- The Paulson Institute has published a 'Blueprint of coastal wetland conservation and management in China' programme since 2016.
- The Asian Development Bank has launched a major Regional Flyway Initiative. This is a large-scale development financing mechanism to appropriately manage 50-100 priority wetlands of the East Asian-Australasian Flyway (EAAF), while leveraging their co-benefits for coastal communities. PRC will have access to this funding mechanism for enhanced management of key sites in the Yellow Sea.
- PRC has revised many laws including the Wildlife Law, Wetlands Law, laws relating to National Parks, and regulations controlling the placement of wind farms. It has also promoted policies on restoring fishponds to natural wetlands in protected areas, regulations on the release of pollutants, seasonal fishing bans and a plan to eradicate 90% of invasive alien *Spartina* cordgrass by 2025.
- PRC has introduced a process of ecological red lining, including marine ecological red lines, to secure critical ecological areas from harmful development.
- ROK's Wetlands Conservation Act was amended in 2016, tightening regulations relating to the establishment of Wetland Protected Areas.

---

<sup>5</sup> EAAFP 2016

- Following publications of its revised Wetlands Inventory in 2018, DPRK has announced a priority wetlands list, which covers the west coast.

### 1.3 Time to act

This comprehensive review enables the identification of new solutions and conservation actions to combat ongoing environmental degradation. These include:

- Urgent remedial actions, including halting further land claims across all countries;
- Expanding the area of natural ecosystems under protection to fill crucial gaps identified in this report;
- Management of *Spartina* cordgrass and other invasive alien species;
- Controlling the discharge of toxic pollutants;
- Improved controls over aquaculture and mariculture activities to manage their negative impacts on marine ecosystems, whilst strengthening their benefits to waterbirds;
- Other urgent actions required include improved planning and siting of wind farms, the release of riverine sediments and freshwater from heavily managed river catchments, and bans on destructive fishing methods and overfishing.

It is critical that actions are taken to combat and mitigate the known and forecasted effects of climate change and reduce damage to extensive agriculture, aquaculture and coastal infrastructure from storms and sea level rise.

It is also vital to underpin the management of the coast by strengthening the physical, social and biological monitoring of coastal ecosystems in the Yellow Sea, and developing an accounting system for its natural capital. This will enable decision makers to monitor the health of the Yellow Sea ecosystem, and alert them to ongoing and new problems while also measuring the effectiveness of conservation interventions.

## 2 BACKGROUND

The Yellow Sea is a shallow epicontinental sea with an average and maximum depth of 44 m and 103 m, respectively (Figure 1). It formed due to sea level rise after the Last Glacial Maximum and is bounded by three countries: ROK, DPRK, and PRC.

Large quantities of silt feeding into the Yellow Sea from large rivers in the west (Yellow River and Yangtze) and smaller rivers in the east (Yalu, Daedong, Han, Geum and Yeongsan rivers) over the last 9,000 years have contributed a large volume of terrigenous sediment. The sediment is redistributed around the shores by tides and waves, where it settles to develop into some of the most extensive mud and sand flats on Earth. The Yellow Sea coastline is primarily fringed by these tidal flats and, in areas with large tidal range and low-sloping intertidal flats, may be up to 20-km wide.<sup>6</sup>

The mud flats and sand flats of the Yellow Sea are immensely productive, with communities of fish and invertebrates supporting diverse bird and marine mammal assemblages. Tidal wetlands in the Yellow Sea are of immense value to human communities, providing billions of

---

<sup>6</sup> Healy et al. 2002



dollars per year in ecosystem services,<sup>7</sup> including blue carbon sequestration, and buffering one of the most densely populated coastal areas in the world from the impacts of storms and sea-level rise.<sup>8</sup> Around 200 million people inhabit the low-elevation coastal zone in this region, with large ports, coastal aquaculture, rice agriculture, and urban areas covering much of the Yellow Sea coastline.

Owing to rapid urban, industrial, and agricultural expansion in the region over the last 50 years, coastal ecosystem integrity and threatened species conservation<sup>9</sup> have become issues of local and international environmental significance. Considerable degradation of the Yellow Sea's coastal environments recently led to the principal coastal ecosystem of the region, the Yellow Sea tidal flats, being listed as *Endangered* under criteria set by IUCN.<sup>10</sup>

The Yellow Sea, including Bohai Bay in the north-west, is considered one of the most important and critically threatened areas globally for migrating shorebirds. It constitutes a vital migratory bottleneck and staging area for shorebirds and other waterbird species migrating through the EAAF. Of all the world's recognized flyways, the EAAF ranks first in terms of total numbers of birds, diversity of species, and numbers of species of globally threatened and near threatened taxa. With migratory bird populations that rely on Yellow Sea coastal habitats collapsing over the past few decades, the region and the status of its natural environment has become a focus of international concern.

Environmental conditions and processes within the Yellow Sea are highly variable over its geographic range. This is primarily a result of variation in abiotic processes and geomorphological environments. In short, tidal waves originating from the Pacific Ocean enter the Yellow Sea and move counter-clockwise (Figure 2), resulting in a large tidal range along the eastern shores of between 3.5 and 10 m., whereas tides in the northern and western coasts range from less than 2 m to around 3.5 m.

In addition, differing geological histories have resulted in a rugged and archipelagic shoreline that contains over 3,000 rocky islands and highly complex coastal topography. The northern and western coasts, besides the intrusive Shandong Peninsula, are less rugged and more influenced by deltaic processes. The unique north-western corner of the sea is the semi-enclosed Bohai Bay (Bohai Sea), with the most reduced tidal action and a consistently shallow sea bed.

The distribution of sediments around the Yellow Sea is also influenced by surface conditions, with seasonal changes as a key driver of the total extent of exposed tidal flats. Winter storms and winds, which prevail generally from the north and northwest, cause erosion of mudflats and change the surface sediment distribution, especially in the eastern coastal area which is exposed to a long fetch. In contrast, reduced wind action, warmer currents from the south and high riverine input of sediments associated with the summer monsoon result in conditions where sediments generally accrete.

---

<sup>7</sup> MacKinnon et al. 2012; Davidson et al. 2019

<sup>8</sup> Small & Nicholls 2003

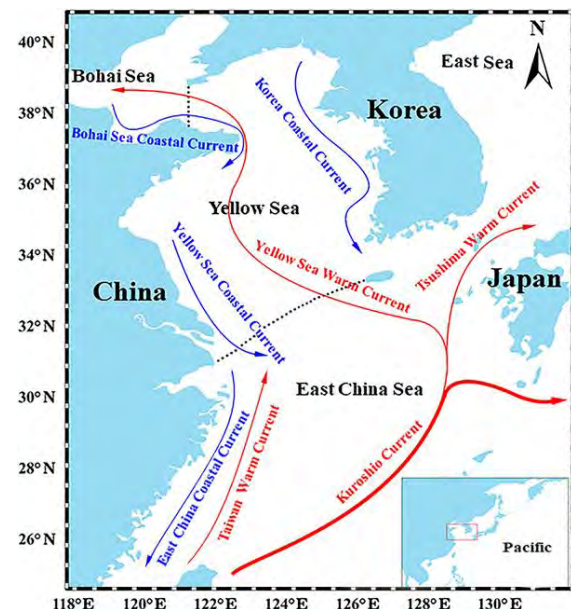
<sup>9</sup> MacKinnon et al. 2012

<sup>10</sup> Murray et al. 2015; IUCN 2018

Additionally, the composition of sediments, particularly in terms of grain size, is variable across the sea and can influence deposition and suspension rates, as well as the biotic communities that inhabit them. The Yellow Sea therefore supports a range of tidal flat types, including muddy shores (mud flats), sand banks, sandy mud flats, muddy sand flats, sand flats and tidal beaches. The full diversity of tidal flats across the Yellow Sea require protection to achieve conservation of the entire range of unique Yellow Sea biota.



**Figure 1 Bathymetry and distribution of surface sediments in the Yellow Sea (Koh & Khim 2014).**



**Figure 2 Main currents in Yellow Sea (Ma et al. 2019a).**

### 3 REVIEW METHODOLOGY

For the purposes of this review, the Yellow Sea is defined as the seas and bays (including Bohai) to the north of the South China Sea with a southern boundary taken as the line between Shanghai to Jeju Island and north to the southwestern corner of the Korean peninsula. This area involves three sovereign states: DPRK, PRC and the Republic of Korea ROK.

This review aims to provide an overview of regional wetland trends, biodiversity and ecosystem services of the Yellow Sea, including an assessment of important sites, threats to intertidal wetlands and their ecosystem services, an analysis of the policy and conservation frameworks, and recommendations for wetland policy makers and managers. The intent of the review is not to be fully comprehensive, considering the vast amount of references and research completed on the Yellow Sea, but to gather some of the key elements published since 2012.

The review builds on the 2012 *IUCN Situation Analysis*<sup>11</sup>, updating it in several ways:

- A review of an additional 10 years of available data and publications;

<sup>11</sup> Mackinnon et al 2012

- Updated spatial analyses of new geospatial data relevant to the Yellow Sea region, including spatial protection measures implemented or planned at different sites;
- A review of relevant publications to support an updated synthesis of information about the degradation and loss of intertidal habitats;
- Improved data on levels of pollution (plastics, oils, eutrophication, Dichloro-Diphenyl-Trichloroethane (DDT), antibiotics) and their impacts on biota;
- A review of trials in controlling invasive alien species;
- A review of publications on the marine physical and biotic resources;
- Inclusion of climate change data, impacts and projected models; and
- Summary of new measures taken to strengthen conservation of the Yellow Sea Ecosystem.

#### 4 IMPORTANCE AND VALUES OF YELLOW SEA HABITATS

##### Box 3 Summary of the importance and values of the Yellow Sea

- Globally unique intertidal ecosystems that are among the largest on Earth, as recognised by recent World Heritage inscriptions.
- A vital stopover and migratory bottleneck that supports the migration of waterbirds through one of the most important global flyways in the world.
- Region-wide fisheries of great significance to all three countries, contributing 30% of all fisheries of the three countries.
- The most important mariculture production area globally and increasing.
- Provides essential ecosystem services for approximately 200 million people living in the Yellow Sea low-elevation coastal zone. Service provision includes sequestration of blue carbon, protecting coastal communities from the impacts of climate change including increased flood risk, and a nature-based tourism industry that supports coastal livelihoods.

The Yellow Sea spans 9° of latitude and the climate varies from north to south. Coastal wetlands that fringe the Yellow Sea coastline include several habitat types that include estuarine wetlands, tidal marshes, rocky coasts, sandy and muddy intertidal flats, seagrass beds and deeper marine waters. Across the Yellow Sea, these habitats and micro-habitats support a high diversity of terrestrial and marine species. Among them, more than 77 migratory bird species rely on Yellow Sea coastal habitats to complete their migratory stop-overs, which frequently involve sequential stop-overs over several staging sites to refuel during their migration.

##### 4.1 Terrestrial zone (IUCN Terrestrial and Freshwater Realms)

The terrestrial coastal zone natural habitats include freshwater reedbeds and wetlands, coastal forests and supralittoral coastal habitats. Across the region, rocky islets that are heavily influenced by marine inputs such as salt spray support roosting and breeding sites for seabirds and other waterbirds. In these terrestrial environments, forest patches and bamboo support breeding sites for several species of waterbirds. In addition, shorebirds utilise a variety of terrestrial habitats for high-tide roosting sites. Transitional systems, such as brackish estuarine habitats and river deltas also support a mixture of marine and freshwater species.

## 4.2 Intensive land-use systems biome

Anthropogenic habitats in the Yellow Sea include saline and freshwater fishponds, salt pans, rice fields and other agriculture, as well as areas transformed to urban and industrial areas. In these habitats, migratory shorebirds and waterbirds frequently forage and roost in habitats including salt pans,<sup>12</sup> ponds and rice fields. Cranes, geese and swans also frequently utilise agricultural land.

A key issue for maintaining the Yellow Sea's important role as a migratory bottleneck is the maintenance of terrestrial roosting sites. Unfortunately, much of the higher coastal zone typically used for roosting is the first to suffer land claim, and it is now thought that the availability of high tide roost sites is a major limiting factor affecting shorebird populations. Shorebirds are now frequently observed roosting in a wide range of anthropogenic habitats, where disturbance and the likelihood of injury is higher than in natural habitats. The practice of appropriately managing working coastal wetlands such as salt pans, aquaculture ponds and rice-fields for shorebirds is widespread globally, and offers an option to manage these environments for the benefit of migratory shorebird populations.

## 4.3 Intertidal zone (IUCN Coastal Realm – Rocky, Sandy and Muddy shoreline biomes)

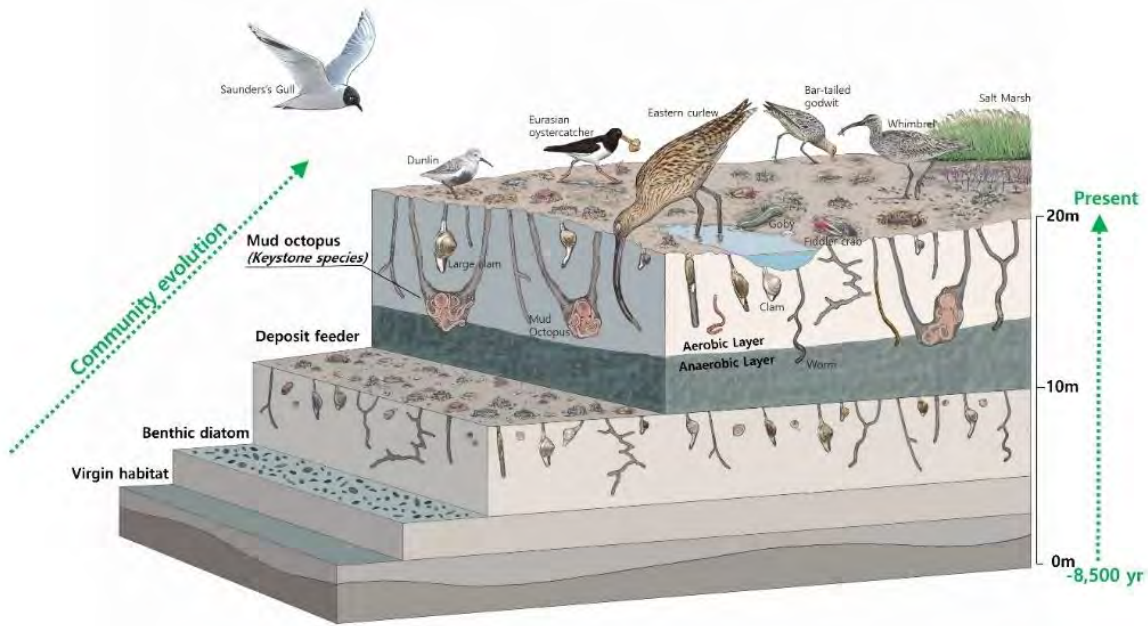
The intertidal zone is the habitat between the high tide waterline and low tide water line. Owing to low-sloping coastal plains, high sediment availability, high tidal amplitude and low-energy environments across the coastline, the intertidal zone of the Yellow Sea is typically characterized by extensive tidal flat ecosystems. In some areas, such as at Incheon, ROK, and inner Gyeonggi Bay, DPRK, the magnitude of the highest tide regularly reaches 9.5 meters, consequently exposing tidal flats over 20-km width. Around the Yellow Sea, tidal flats vary in sediment grain size from fine-silt to coarse sand, and support a diverse invertebrate fauna which is a vital food resource for shorebirds and other waterbirds, fish, crabs and molluscs, as well as being gathered for food by humans.

At higher elevations of the intertidal zone, coastal saltmarsh ecosystems occur (Figure 3). These ecosystems are periodically inundated at high tide and are characterized by salt tolerant grasses and succulents, including *Suaeda*. They generally occur as mosaics of vegetation and open mudflat that are defined by fine-scale variability in salinity and hydrology and interactions between vegetation and sediments.<sup>13</sup>

---

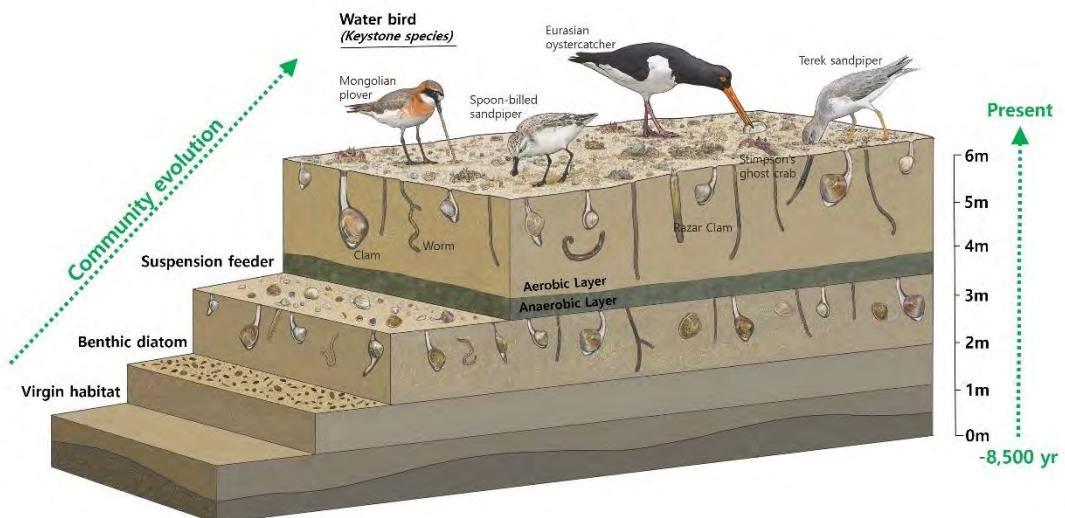
<sup>12</sup>Jackson et al. 2020

<sup>13</sup> Keith et al. 2020



**Figure 3 Schematic diagram of the community evolution on mud flat habitat (Cultural Heritage Administration, Republic of Korea 2019).**

Sand bars and sand flats support a different assemblage of benthic invertebrates and are a physically unique foraging habitat for waterbirds (Figure 4). Some species of waterbirds display a preference for sand flats.



**Figure 4 Schematic diagram of community evolution on sand bar habitat (Cultural Heritage Administration, Republic of Korea 2019).**

Rocky coastlines support a smaller suite of shorebirds, herons, Black-faced Spoonbills (*Platalea minor*) and seabirds.

#### 4.4 Deeper marine sections (IUCN marine shelf and anthropogenic structures biomes)

Most of the Yellow Sea is relatively shallow with an alluvial floor that, across the sea, is at an average of around 40 m. The entire marine area is heavily fished for many economically important species of fish and invertebrates (crabs, prawns, squid and jellyfish). In addition to forming a complex food web within the marine environment, these species are sometimes washed ashore, where they support coastal seabirds including gulls and terns. Many marine species utilise the intertidal zone and shallow inshore waters as nursery areas.

The deeper marine section of the Yellow Sea supports marine mammals, as well as sea ducks in winter, which use both coastal and offshore waters. Upwellings and tidal fronts are a key driver of the spatial distribution of foraging seabirds. Seasonal changes in species composition are typically driven by species migration, with species including loons present in winter, and murrelets, Streaked Shearwaters (*Calonectris leucomelas*) and Swinhoe's Storm-petrels (*Oceanodroma monorhis*) occurring primarily in the summer. Terns occur during their migration and gulls are present throughout the year.<sup>14</sup>

Of the marine mammals, Spotted Seals (*Phoca largha*) usually occur near the coastal zone, while the narrow-ridged Finless Porpoise (*Neophocaena asiaeorientalis*) occurs seasonally in both inshore and offshore marine waters, sometimes together with other species of cetaceans.

## 5 DRIVERS AND THREATS TO THE HEALTH OF THE YELLOW SEA

### Box 4 Drivers and Threats

- The rate of coastal land claim has slowed, but some claims continue. The total area of land claims from 2010-2020 is 64% less than the previous decade. There is now more land claimed area than remaining intertidal habitat.
- The Yellow Sea tidal flats ecosystem has been listed as globally endangered under the IUCN Red List of Ecosystems, due to impacts on its biotic and abiotic features.
- Reduced river sediment discharge into the Yellow Sea tidal flats ecosystem is causing changes in the distribution and quality of inter-tidal habitats, and erosion of coastal ecosystems including tidal flats.
- Poorly sited or designed wind farms and solar energy farms, together with other large infrastructure developments, constitute a potential threat of mortality to migratory birds through collision and competition for space.
- Over-harvesting of seafood, together with ecological threats related to unsustainable aquaculture and mariculture practices, are leading to the degradation of natural environments.
- Invasive species are emerging as a serious threat to both marine and inter-tidal ecosystems, especially through competition for space.
- Pollution from human waste, farming practices and industry is a threat to wildlife and human health.

---

<sup>14</sup> Moores 2012

- Climate change is already causing damage to the natural ecosystems of the Yellow Sea, with rising sea level, temperature and extreme weather events leading to changes in biota and the loss of intertidal habitat. Future changes are expected to result in the loss of coastal habitat and increased flood risk to human populations.
- Increased risk of zoonosis due to avian influenza, avian botulism and other potential diseases is a threat to both wildlife and humans.

A wide range of threats are impacting the biodiversity and ecological health of the Yellow Sea (Box 4). This section synthesises the nature and scale of threats, the drivers behind these threats, the biodiversity being affected, the general trend of each threat and suggested mitigation measures.

### Case Study 1 Lianyungang/Haizhou Bay

Lianyungang Salt Works, Jiangsui was included in the World Heritage Tentative List entry of the PRC submitted to UNESCO in February 2017.

The coast of the Lianyungang area, Jiangsu is the third most important area on the Chinese coast in terms of the number of waterbird species occurring in internationally important numbers.<sup>15,16,17</sup> The area supports 1% or more of the global/EAAF populations of 30 species of waterbird, including four 'Endangered,' three 'Vulnerable' and nine 'Near Threatened' species.

More than 90% of the world population of the Near Threatened Asian Dowitcher (*Limnodromus semipalmatus*) stages in the Lianyungang area on northward migration,<sup>18</sup> making the area the most important site in the world for this species. The soft intertidal sediments, in particular at the Linhong and Qingkou estuaries, support high densities of large polychaete worms<sup>19</sup> that provide a vital food resource for Asian Dowitchers on migration. Smaller numbers of Asian Dowitchers use the site on southward migration (but still 16-28% of the world population).

The coast of Haizhou Bay, Lianyungang is composed of soft sediments in the southern area but the beaches to the north are sandy; there is also a salinity gradient from north (higher salinity) to south (lower salinity).<sup>20</sup> This provides a variety of habitats and associated benthic infauna that provides food for the great array of waterbirds; very high densities of the clam *Potamocorbula laevis* are present, as well as other small, soft-shelled bivalves.<sup>21,22</sup> Satellite tracking of individual birds, including Great Knots and Bar-tailed Godwits has highlighted how different species utilise different areas within the proposed boundary of the site. Unpublished satellite tracking data for the Asian Dowitcher confirm that they are largely restricted to Linhong and Qingkou estuaries.

<sup>15</sup> Bai et al. 2015

<sup>16</sup> Chan et al. 2019

<sup>17</sup> Choi et al. 2020b

<sup>18</sup> Yang et al. 2021

<sup>19</sup> C.Y. Choi, unpublished

<sup>20</sup> Zhu et al. 1998

<sup>21</sup> Chan et al. 2019.

<sup>22</sup> Peng et al. 2021.

On 12 May 2021, a total of 27,000+ Asian Dowitchers were recorded in Qingkou and Linhong estuaries, which accounted for 95% of its global population. This is the third consecutive year that more than 20,000 Asian Dowitchers have been recorded in a single day.

Various experts consulted by IUCN consider that the coast of the Lianyungang area, Jiangsu is a critical site due to the diversity of waterbird species present, the variety of habitats used and linkages between foraging and roosting sites, and therefore suggest consideration of the site as a component in a World Heritage nomination under criterion (x) (“contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value (OUV) from the point of view of science or conservation”).

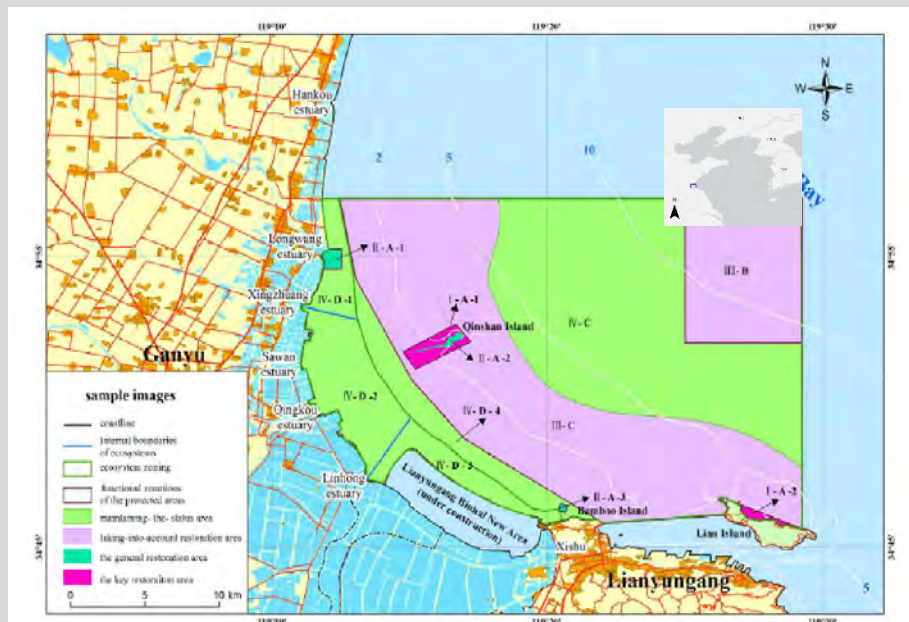


Figure 5 Boundary of Haizhouwan National Marine Park (Li et al. 2014)

### Protected areas in Lianyungang

Haizhou Bay includes 515 km<sup>2</sup> of National Marine Park, established in 2008, to protect the ‘island coastal landforms as well as native bay floral and faunal resources.’<sup>23</sup> The National Marine Park boundary includes all intertidal flats along the coast between Xishu and Longwan Estuary (Figure 5). There are also a number of other protected areas, including: Ganyu Sandy Coast Nature Reserve, Qinshan Island Marine Abrasion and Accumulation Landform Reserve, Songzhuang Marine Abrasion and Accumulation Landform Reserve, and Zhudao Island Marine Abrasion and Accumulation Landform Reserve.<sup>24</sup>

All of the intertidal flats between Xishu and Longwan Estuary are used for foraging by important numbers of shorebirds and could be. The area is already included within the Haizhouwan National Marine Park (Figure 5). Shorebirds are currently using aquaculture

<sup>23</sup> Li et al. 2014

<sup>24</sup> Feng et al. 2014



ponds and unused reclaimed land as high tide roost sites, therefore an area landward of the current seawall is also important.

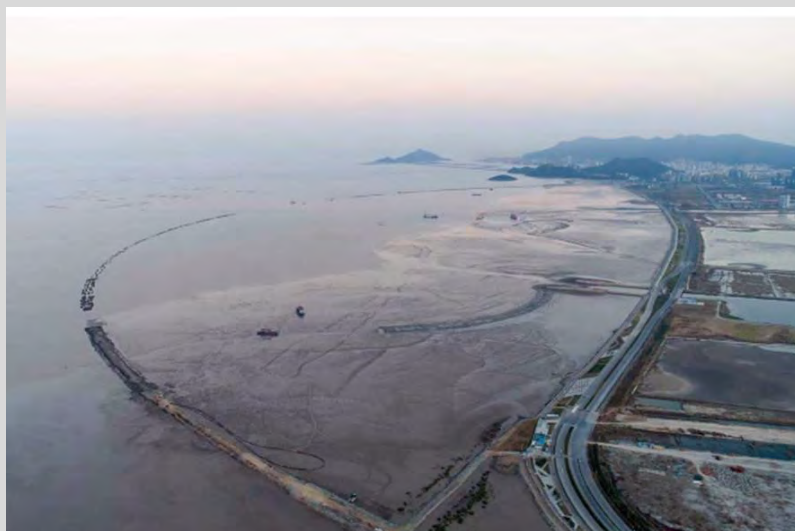
### **Threats**

Lianyungang is a strategic city in the Belt and Road Initiative, serving as the eastern railhead for the project. As such, it is developing rapidly and there has been a reduction in the area of salt ponds, which have been converted to urban development. Coastal land claims have largely stopped following the State Council's 2018 Circular on controlling land claim. However, the 'Blue Bay' project is currently constructing a seawall to enclose 1,870 ha for the development of a tourist and recreation area. A legal case has been taken against the developer and is currently being heard by an 'Environment Court.'

The Blue Bay project includes the development of a 'wetland park' which, as currently designed, would be of little value to native biodiversity. There is, however, an opportunity to develop an international standard nature reserve and high tide roost site for shorebirds. Currently most waterbirds roost in aquaculture ponds and unused reclaimed land along the coast, but as these become increasingly developed, roost sites will be at premium – the careful development and management of suitable habitats in the wetland park could be of great conservation benefit and provide a unique tourist spectacle especially during the Asian Dowitcher migration period.

It is not known whether the new Blue Bay seawall (Figure 6) will result in changes in hydrology and sedimentation. If the sediments at the Linhong estuary become coarser, this could result in changes in benthos, which might reduce suitable prey and foraging conditions for Asian Dowitchers, for which the site is of global importance. Contamination of the coastal sediments may also be a matter of concern – elevated mercury levels were reported by Huang et al. (2008)<sup>25</sup> and of arsenic by Li et al. (2019).<sup>26</sup>

Other threats include an expansion of *Porphyra yezoensis* seaweed farming in Haizhou Bay since 2002, the effects of which on coastal ecology are unknown. The invasive alien *Spartina alterniflora* cordgrass is also present and reported to be spreading. Control by a herbicide such as haloxyfop is probably required, but requires trials to assess impacts on benthos, although no impacts were found when it was applied at Chongming Dongtan.<sup>27</sup>



**Figure 6 Aerial view of Blue Bay land claim project, showing the nearly completed seawall © Dihai Chen**

## 5.1 Threats causing habitat loss/degradation

### 5.1.1 Changes in the extent and distribution of coastal ecosystems

Tidal flats in the Yellow Sea are among the largest on earth; in areas with high tidal amplitude and low sloping coastlines (macrotidal, > 3.5 m),<sup>28</sup> they may attain a width of nearly 20 km when exposed at low tide.<sup>29</sup>

Although the majority of tidal flats are along the open coast and in embayments, in some areas tidal flats occur offshore. For example, the extensive Jiangsu Radial Sand Ridge system including Dongsha Shoals that occurs offshore in southern Jiangsu province of PRC, is a globally unique geomorphological feature of enormous significance to migratory shorebirds, gulls, terns and other waterbirds. These offshore tidal flats are 'dozens of kilometres' wide and have an estimated extent of more than 1,250 km<sup>2</sup>.<sup>30</sup>

In addition, 2,290 (78.5%) of ROK's 2,918 uninhabited islands are on the Yellow Sea coast, providing critical habitats for migratory shorebirds on the southwestern coast of the Korean peninsula.

Yellow Sea tidal flats are dependent on ongoing sediment supply and substantial declines of sediment output from major rivers in the region, such as the 90% decline in sediment flow from the Yellow River during the 20<sup>th</sup> century, could be contributing to broad-scale tidal flat loss on the western coast of the sea.

Consequently, although coastal land claim is the principal driver of extensive tidal flat losses in the Yellow Sea, processes such as changes in sediment supply, loss of coastal vegetation associated with development, replacement by invasive alien species, erosion, redistribution of sediments due to storms, and compaction and subsidence (sinking) caused by subsurface resource and groundwater extraction are also likely to be factors.<sup>31</sup> The erosion and resedimentation by winter storms and summer typhoons also play an important role for various habitat conditions.

Sediments are transported to the tidal flats by coastal and tidal currents, where the deposition is influenced by the sediment type, vegetation, wave dynamics, and biotic effects. However, unlike most other tidal flats, the Yellow Sea tidal flat ecosystem is largely erosion dominated, requiring ongoing sediment replenishment and transport to persist.<sup>32</sup> These biophysical processes of change are expected to be interacting at multiple spatial scales, such that the combined effects of coastal land claim and other indirect drivers of change are likely to exceed the impacts of each one if they were operating in isolation.<sup>33</sup>

---

<sup>25</sup> Huang et al. 2008

<sup>26</sup> Li et al. 2019

<sup>27</sup> Zhao et al. 2020

<sup>28</sup> Flemming 2005

<sup>29</sup> Healy et al. 2002; Wang et al. 2014

<sup>30</sup> Liu et al. 2012 ;2013

<sup>31</sup> Syvitski et al. 2009; Nicholls & Cazenave 2010; Higgins et al. 2013

<sup>32</sup> Healy et al. 2002; Wang et al. 2014

<sup>33</sup> Murray et al. 2015

### 5.1.2 Historical tidal flat losses (1950s – 2000s)

Historical land claims for agriculture, aquaculture, and industrial land uses have transformed the Yellow Sea coastline and led to an alarming decrease in the extent of Yellow Sea tidal wetlands over a 70-year period (Figure 7, Table 1).<sup>34,35,36</sup> Coastal land claims cause direct losses of tidal flats and other coastal ecosystems, and the extent of coastal land claims now exceeds the extent of remaining coastal wetlands (Figure 8, Table 2).<sup>37</sup>

**Table 1 Estimates of the historical change of tidal flat extent in the Yellow Sea, by country, between the 1950s and 2000s.**

	Estimated Area (ha)			% Change
	1950s	1980s	2000s	1950s-2000s
PRC	539,794	267,751	161,066	-70.2%
DPRK	231,813	99,333	107,765	-53.5%
ROK	350,331	177,729	120,472	-65.6%
<b>Yellow Sea</b>	<b>1,121,938</b>	<b>544,812</b>	<b>389,303</b>	<b>-65.3%</b>

Source: Murray et al. (2014)

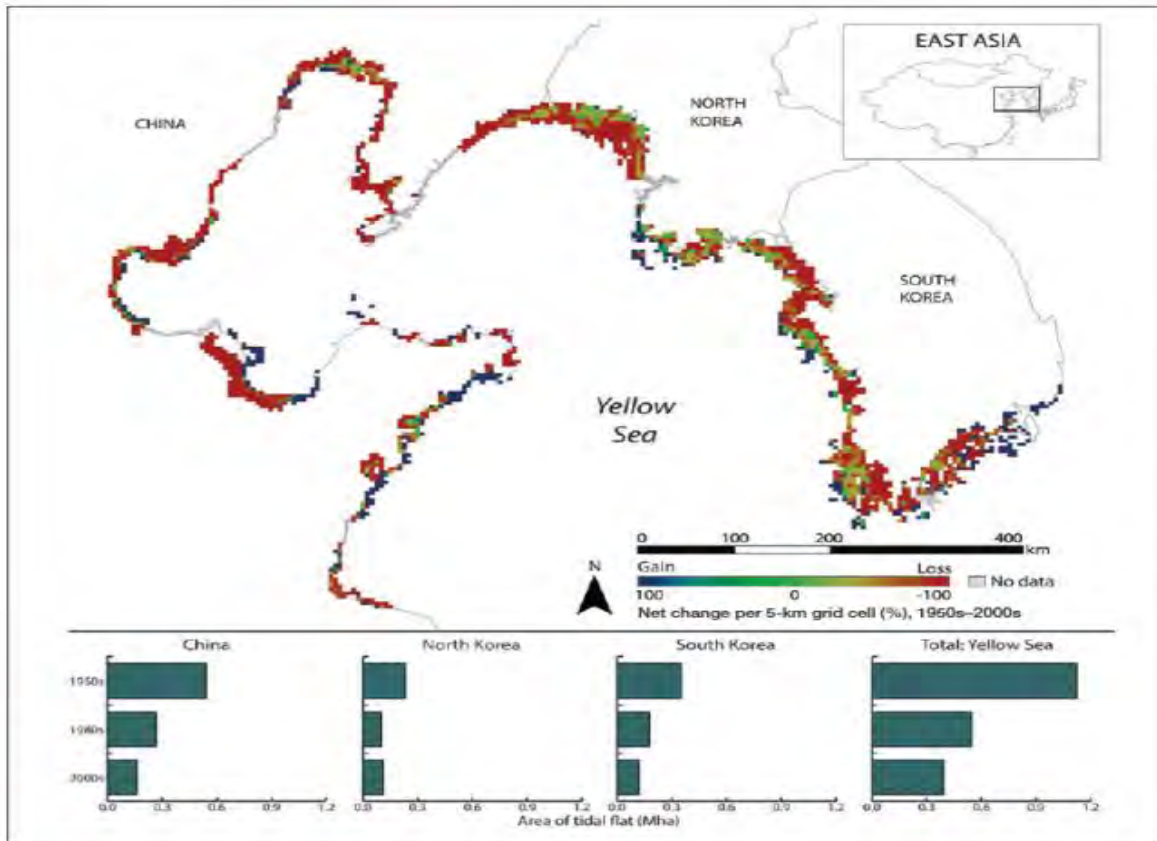
---

<sup>34</sup> Murray et al. 2014

<sup>35</sup> Yim et al. 2018

<sup>36</sup> Wang et al. 2021

<sup>37</sup> Yim et al. 2018

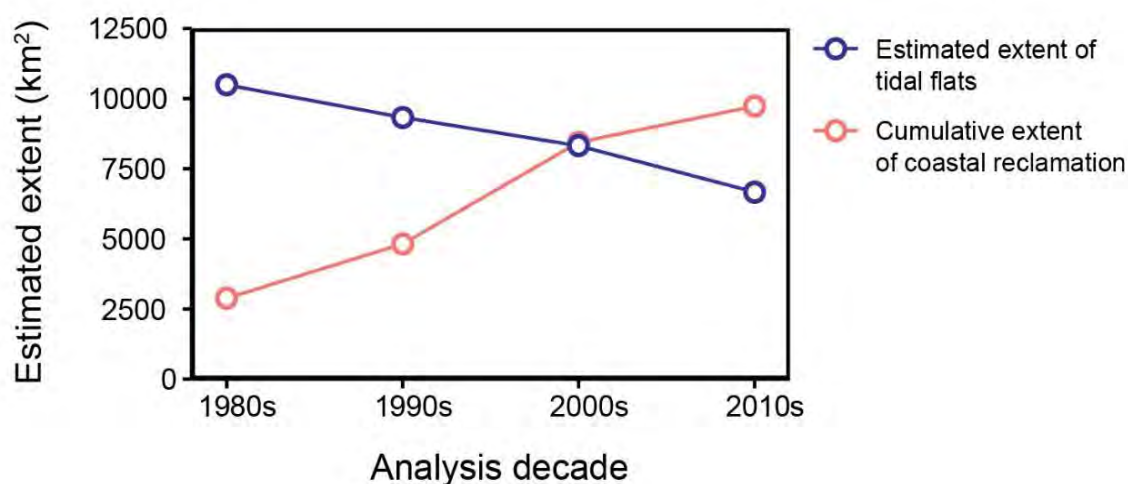


**Figure 7 Change in tidal flats in the Yellow Sea between the 1950s and the 2000s mapped at a 5-km grid resolution. Net change between the two time periods is shown on a color ramp from blue (total gain) to red (total loss) (Murray et al. 2014).**

Note: Area estimates should be considered minima for the Yellow Sea, because 12.1% of the coastline could not be mapped owing to the presence of cloud or ice cover in satellite imagery obtained at suitable tide heights.

**Table 2 Recent estimates of the extent of tidal flats and reclaimed land in the Yellow Sea. The cumulative area of reclaimed land exceeded the estimated extent of tidal flats in the last decade of the 20<sup>th</sup> century. Note that decadal estimates cover a 10-year period. (Yim et al. 2018).**

Period	Land claimed area estimate (km <sup>2</sup> )	Cumulative land claimed area since 1980 (km <sup>2</sup> )	Tidal flat extent estimate (km <sup>2</sup> )
1980-1990	2,884	2,884	10,486
1990-2000	1,935	4,819	9,327
2000-2010	3,622	8,441	8,315
2010-2020	1,286	9,727	6,668



**Figure 8 Extent of tidal flats in relation to the cumulative area of land claims in the Yellow Sea since the 1980s (Yim et al. 2018).**

### 5.1.3 Recent tidal flat losses (2000-2019)

Several studies have suggested a slowing of tidal flat losses in PRC in the last decade,<sup>38,39</sup> after continued and accelerating declines in tidal flat extent over several decades. However, recently developed Yellow Sea-wide data on the change of tidal wetlands (saltmarshes and tidal flats) suggests that the losses of tidal flats still exceed gains in tidal flats, and that a net loss of tidal flats has continued (Figure 9, Table 3).

The vast majority of losses over the last two decades were recorded along the PRC coastline of the Yellow Sea, which includes areas such as Bohai Bay and the Jiangsu coast (89.6% of Yellow Sea total).

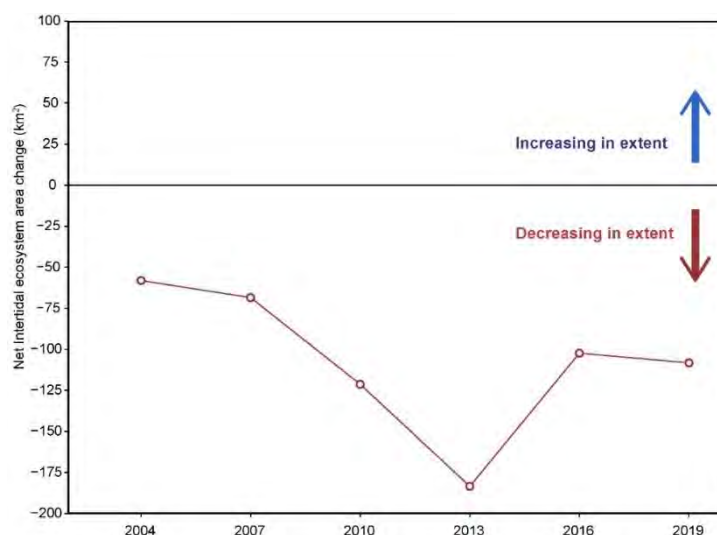
Despite some continuing land claims near Incheon, with some exceptions, losses of tidal flats in ROK appear to have largely stabilised. Minor observed gains in tidal wetland extent may be the result of saltmarsh growth on formerly reclaimed areas and recent restoration efforts by the ROK Ministry of Oceans and Fisheries.

In DPRK, the impact of new coastal land claims is evident in the remotely sensed data. Continued high-resolution satellite monitoring programmes that can simultaneously monitor land claim extent and ecosystem losses are therefore critical to assess the impact of new coastal conservation measures, restoration activities and policy actions.<sup>40</sup>

<sup>38</sup> Wang et al. 2021

<sup>39</sup> Murray et al. 2022

<sup>40</sup> Murray et al. 2019



**Figure 9 Net loss of tidal wetlands in the Yellow Sea per 3-year analysis period from– 2004 - 2019 (Data from [www.globalintertidalchange.org](http://www.globalintertidalchange.org)).<sup>41</sup>**

Tidal flat losses have occurred for every 3-year time-step of the last two decades (Table 3), suggesting ongoing and widespread impacts of threats such as land claim and disruption of coastal processes are having an ongoing negative impact on the Yellow Sea’s coastal ecosystems.

**Table 3 Losses and gains of tidal wetlands (tidal flats and saltmarshes) in the Yellow Sea from 1999-2019 (Data from [www.globalintertidalchange.org](http://www.globalintertidalchange.org)).**

Country	Tidal wetland gain area (km <sup>2</sup> )	Tidal wetland loss area (km <sup>2</sup> )	Tidal wetland net change (km <sup>2</sup> )	Contribution to Yellow Sea loss area (%)	Contribution to Yellow Sea gain area (%)	Percent total net change in Yellow Sea (%)
ROK	121	-114	7	7.2	10.4	-1.6
DPRK	77	-128	-51	8.1	6.6	12.0
PRC	967	-1349	-383	84.8	83.0	89.6
<b>Total</b>	<b>1165</b>	<b>-1591</b>	<b>-427</b>	<b>100</b>	<b>100</b>	<b>100</b>

The data show that the vast majority of tidal wetland losses have occurred in the PRC part of the Yellow Sea over the last two decades as a result of coastal land claim and indirect threats such as sediment declines, erosion and subsidence. Note that global intertidal change data can include gains in extent due to vegetation growth such as *Spartina* on recently reclaimed areas.

#### 5.1.4 Land claim

The biggest component of intertidal habitat loss is land claim, which is considered an existential threat to tidal flats and associated habitats in the Yellow Sea. Land claim, defined

<sup>41</sup> Murray et al. 2022

as the conversion of natural coastal wetlands into terrestrial areas and artificial wetlands by artificial means,<sup>42</sup> is the main cause of loss of around 65% of the Yellow Sea's tidal flats between the 1950s and 2000s.<sup>43</sup> The area of coastal land claims developed over the last 40 years around the Yellow Sea coastline has been estimated to be between 9,700km<sup>2</sup><sup>44</sup> and 10,500km<sup>2</sup>,<sup>45</sup> which now exceeds the most recent estimate of the area of remaining tidal flats in the region (6,668 km<sup>2</sup>) (Table 2). Land claims are primarily undertaken for the purpose of aquaculture, agriculture for rice farming, port developments, coastal defence and industrial activities.

According to a recent analysis,<sup>46</sup> around half of the world's total area of marine construction is in PRC and ROK making them the top two countries globally for such development, which includes artificial islands, breakwaters, coastal defences such as seawalls. Seawalls alone are implicated in the loss of at least 10,000km<sup>2</sup> of tidal flats and shallow sea in the Yellow Sea since the 1950s<sup>47</sup>(Table 4, Figure 10).

Coastal land claims can have a variety of indirect impacts on the Yellow Sea ecosystem. For example, reclaimed land has been implicated in an increase in maximum storm surge height, due to a loss of tidal flats that previously dissipated energy during extreme storm events.<sup>48</sup> In addition, the hydrodynamic disturbances associated with extensive coastal land claims is expected to lead to higher tidal amplitudes, increased asymmetry in tides, and may enhance tidal energy in some areas, which could ultimately increase the probability of coastal hazards and increase erosion of tidal flat ecosystems across the region.<sup>49</sup>

Unfortunately, the rapid coastal development in the Yellow Sea has also introduced error into bathymetry and coastline data, which leads to increased uncertainty in models of the predicted future impacts of sea level rise on coastal infrastructure and Yellow Sea ecosystems.<sup>50</sup>

---

<sup>42</sup> Moores 2012

<sup>43</sup> Murray et al. 2014

<sup>44</sup> Yim et al. 2018

<sup>45</sup> Choi et al. 2017

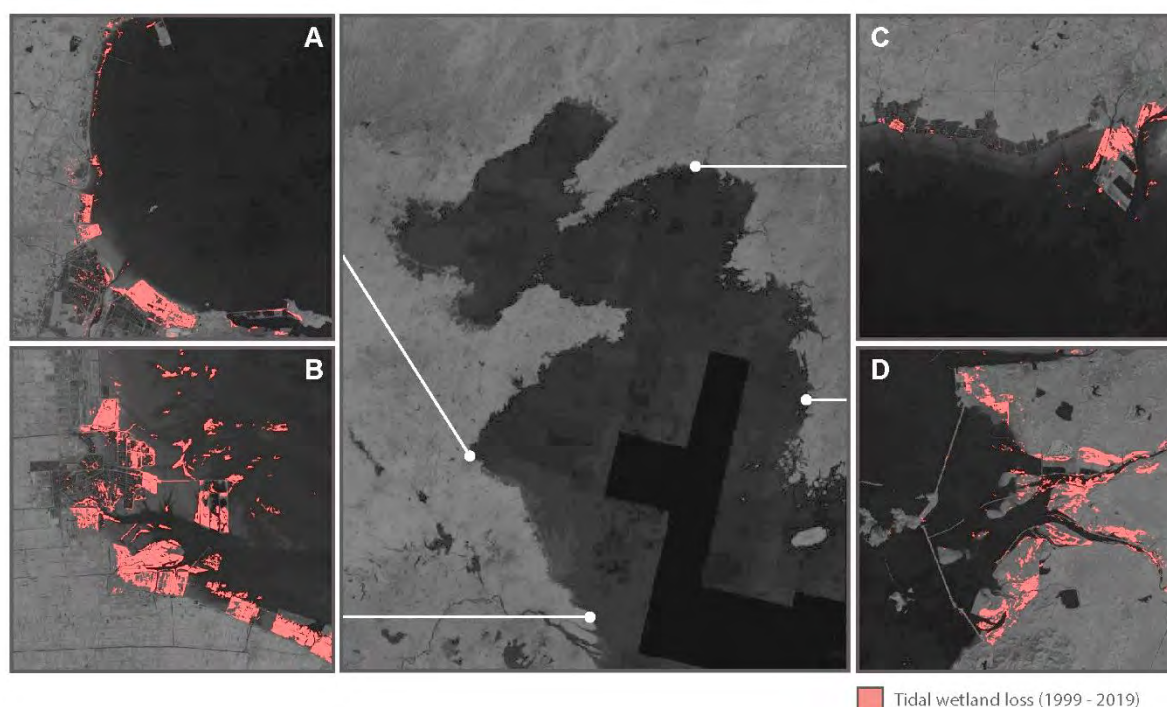
<sup>46</sup> Bugnot et al. 2021

<sup>47</sup> Yim et al. 2018

<sup>48</sup> Lee et al.2020

<sup>49</sup> Zhu et al. 2016

<sup>50</sup> Yang et al. 2011



**Figure 10 Losses of tidal wetlands at four case study sites addressed in subsequent sections. Case study sites are (A) Lianyungang – Haizhou Bay, (B) Yancheng Coast, (C) Yalu River Estuary, (D) Saemangeum Reclamation Project. (Data from [www.globalintertidalchange.org](http://www.globalintertidalchange.org))**

Cautionary note: Such analysis does not reveal that the water empounded within the sea walls e.g. Site D are now no longer tidal and apparent remaining wetlands therein are now vegetated dry islands.

**Table 4 Coastal land claim in the Yellow Sea from 1980 to 2020; accumulated area since 1980 in parenthesis. (Yim et al. 2018)**

Region	Accumulated area of coastal land claim (km <sup>2</sup> )						
	1980-1990	1990-2000		2000-2010		2010-2020	
<b>PRC</b>	<b>2,361</b>	<b>1178</b>	<b>(2,539)</b>	<b>2723</b>	<b>(6,262)</b>	<b>1,105</b>	<b>(7,367)</b>
Liaoning	573	235	(808)	656	(1,464)	253	(1,717)
Hebei	170	86	(256)	431	(687)	150	(837)
Tianjin	19	17	(36)	272	(3,08)	92	(400)
Shandong	1,284	231	(1,515)	797	(2,312)	345	(2,657)
Jiangsu	315	609	(924)	567	(1,491)	265	(1,756)
<b>ROK</b>	<b>368</b>	<b>539</b>	<b>(907)</b>	<b>523</b>	<b>(1,430)</b>	<b>150</b>	<b>(1,580)</b>
Incheon		46	(46)		(46)		(46)
Gyeonggi		211	(211)	62	(273)		(273)
Chungnam	230	56	(286)	14	(300)		(390)
Jeonbuk				401	(401)		(461)
Jeonnam	<b>138</b>	<b>226</b>	<b>(364)</b>	<b>46</b>	<b>(410)</b>		<b>(410)</b>
<b>DPRK</b>	<b>155</b>	<b>218</b>	<b>(373)</b>	<b>376</b>	<b>(749)</b>	<b>31</b>	<b>(780)</b>
<b>Yellow Sea</b>	<b>2,884</b>	<b>1,935</b>	<b>(4,819)</b>	<b>3,622</b>	<b>8,441</b>	<b>1,286</b>	<b>(9,727)</b>



## Coastal land claims in the People's Republic of China

PRC is considered a global hotspot of coastal land claim. The rapid expansion of agriculture, aquaculture, and urban, industrial and port developments has corresponded with a widespread migration of people to the coastlines. A recent PRC-wide estimate indicates that the rate of land claim doubled over the period 2000-2010 from the previous decade.<sup>51</sup> The extent of coastal land claims over the past 70 years has led to a pervasive transformation of the coastline, from a naturally-dominated shoreline in the 1940s (81.7% natural) to a human-dominated system by 2014 (32.9% natural).<sup>52</sup>

A recent estimate of the extent of land claims in PRC's Yellow Sea suggests a total area of coastal reclaimed land of 7,696 km<sup>2</sup>, which caused the loss of at least 1,276 km<sup>2</sup> of saltmarshes and 3,002 km<sup>2</sup> of tidal flats over 30 years.<sup>53</sup> Owing to continued loss of tidal flats to coastal land claims, the sensing evidence suggests that many areas of expanding land claim are now causing losses of shallow marine environments due to local collapses of tidal flat ecosystems.

Tracking the area of tidal wetlands in PRC suggests that habitat losses due to reclamation peaked around 2013, but the inclusion of extensive areas of the Jiangsu coast and the large offshore tidal flats present on the Jiangsu Radial Tidal Sand Ridges, part of which are in the World Heritage Site, in future coastal land claim plans is a remaining concern.<sup>54</sup>

The fate of coastal land claims is varied, and is often associated with a transitional period that starts with sea wall construction, infilling, and then the direct development of agriculture or aquaculture, and finally irreversible conversion to urban and industrial land uses. Over the past three decades the area of reclaimed land in PRC dedicated to aquaculture has increased four-fold, of which the period of fastest transformation was the 1990s.<sup>55</sup> Although these increases are only partly concentrated in the Yellow Sea region, they indicate that the natural coastline has continued to be impacted by a range of land use changes.

Although 578,000 ha of coastal wetland was earmarked for land claim in the various local land-use plans from 2011-2020, several major coastal land claim projects have either been suspended or cancelled.

On 25 July 2018, PRC's State Council published a circular entitled 'Reclaiming land to be restricted.' Under the new regulations, PRC plans to halt and prohibit all business-oriented coastal land claim activities and abolish local governments' authority over the matter. State Oceanic Administration officials have declared that the government will nationalize reclaimed land with no structures built on it and will halt coastal land claim projects that are inconsistent with national policies.<sup>56</sup> The central government will stop approving property development plans based on coastal land claims and will prohibit all land claim activities unless they pertain to national key infrastructure, public welfare or national defence. All structures that are built

---

<sup>51</sup> Wang et al. 2021

<sup>52</sup> Hou et al. 2016

<sup>53</sup> Chen et al. 2019

<sup>54</sup> Chen et al. 2019; Liu et al. 2012

<sup>55</sup> Ren et al. 2019

<sup>56</sup> See Lianyungang Case Study 1

on illegally reclaimed land and that have seriously damaged the marine environment will be demolished.<sup>57</sup>

### **Coastal land claims in the Republic of Korea (ROK)**

Large-scale coastal land claims of tidal flats in RoK have been occurring since at least the 1950s, and initially supported a widespread expansion of rice production along the coastline.<sup>58</sup>

In the mid-1980s a national Masterplan for Land Use identified two-thirds of the ROK's tidal flat and adjacent sea-shallows as fit for land claim, including several sites soon after identified as internationally important for waterbirds.<sup>59</sup> Under legal statutes, the primary use of reclaimed areas was to be agriculture. However, in part because of water quality issues in many of the recently reclaimed areas (e.g. Siwa and Saemangeum), these were later re-zoned by special laws and ordinances to permit industrial development.

Thus, following an initial focus on coastal land claim for agricultural land the focus of land reclamations later shifted to land production for so-called mega-scale coastal land claims for the establishment of new urban and industrial land up to the 1990s.<sup>60</sup>

Following a 22% decline in tidal flat area from 320,400 ha in 1987 to 248,900 ha in 2010, protests began against the Saemangeum Reclamation Project in Jeollabuk province. NGOs and religious communities in RoK, and soon also the general public, began to shun large-scale coastal land claim projects. This popular concern for tidal flats grew rapidly, leading to a formal declaration in 2008 to permit no more large-scale land claim across the RoK coastline.<sup>61</sup>

The Saemangeum Reclamation project, which caused the loss of 27,000 ha of tidal flats and 13,000 ha of sea shallows when the estuary was closed off from the sea by a 33 km long outer sea-dyke in 2006 (Figure 11), was highlighted in the 2012 *Situation Analysis*.<sup>62</sup>

Moores et al.<sup>63</sup> recorded a loss of 92,000 Great Knot (*Calidris tenuirostris*), estimated at 20% of the global population, within three years of seawall closure in 2006; and found that the majority of shorebirds could not relocate successfully to adjacent wetlands or other wetlands within the ROK. As a direct result, the Great Knot was reassessed on the IUCN Red List from being of Least Concern in 2007, to Vulnerable in 2010 and its current status as globally Endangered in 2015.<sup>64</sup>

A few areas within Saemangeum remain internationally important for waterbirds, with an estimated 100,000 Great Cormorant (*Phalacrocorax carbo*) dependent on the reclamation lake and 2% or more of the world population of Black-faced Spoonbill persisting in reclamation lagoons. Although data is patchy, shorebird numbers have not recovered, either locally (declining c. 98.5% between 2000 and 2014: Moores et al. 2016), or nationally.

---

<sup>57</sup> Melville 2018; Zhao Lei 2018

<sup>58</sup> Choi et al. 2014

<sup>59</sup> Long et al. 1988

<sup>60</sup> Choi et al 2014

<sup>61</sup> Ramsar Resolution X.22 Paragraph 22

<sup>62</sup> Mackinnon et al 2012

<sup>63</sup> Moores et al. 2016

<sup>64</sup> BirdLife International 2021

The cost of loss of fisheries within Saemangeum and adjacent marine waters and the loss of “blue carbon” caused by the land claim was not factored into recent discussions on sustainability.

Instead, recent efforts to invite new investment include the proposed construction of the world’s largest solar farm within the Saemangeum reclamation lake. According to media reports, the proposed 2.1 GW Saemangeum solar farm will be 14 times larger than the current floating solar record holder, a 150 MW plant now being built in Huainan, in PRC’s Anhui province.<sup>65</sup> The success of this project at Saemangeum is already being hampered, however, because of the large numbers of waterbirds, including Great Cormorants, which use the solar panels for roosting, covering many of the panels in corrosive excrement.<sup>66</sup>

Since the previous situation analysis a decade ago, government-led large-scale coastal land claim projects have been suspended. However, an exception is made for several large pre-planned coastal land claim projects on the west coast which have either been started (e.g., at Yeongjong Island and Incheon Songdo) or simply continued (e.g., Namyang Bay, Asan Bay and Saemangeum). Rationale for these coastal land claim projects includes their being permitted pursuant to the Masterplan for Land Use and / or because they are now within special economic zones which cover about a third of national land, following passage of the Coastal Zone Development Special Act (2007).<sup>67</sup>

In general, the government plans for land claims of public waters are renewed every 10 years. According to the 4th Public Waters Reclamation Basic Plan (2021-2030), confirmed in August 2021 by the Ministry of Oceans and Fisheries (MOF), local governments and the private sector had applied for a total of 819 ha in 31 locations for small sized land claims, but the plan only contains 101 ha in 24 locations. These coastal land claim projects are for minimized extension of port facilities and public facilities. In future, a land claim license must be obtained according to the prescribed procedures of the Public Waters Management and Reclamation Act, and if a land claim license is not obtained within 5 years, the land claim plan will be cancelled.

The ongoing projects could be cancelled if local government strongly so wished (as in other WH properties).

There has been a significant positive shift in national tidal flat conservation policy e.g. Wetland Conservation Act (2016 revised), the Marine Space Planning and Management Act (2018) and the Tidal Flat and its Surrounding Areas Sustainable Management and Restoration Act (2019) on tidal flat conservation of the government of the RoK.

---

<sup>65</sup> Bellini 2021

<sup>66</sup> Kim 2021a

<sup>67</sup> Kim 2007



**Figure 11 Saemangeum, in 1984 and in 2020. © 2021 Google, Mountain View, USA**

### **Coastal land claims in the Democratic People's Republic of Korea**

In recent history, the rate of land claim in DPRK has been generally much lower than in PRC or ROK,<sup>68</sup> with an estimate of DPRK land claims being less than half of ROK since the 1980s. Nevertheless, coastal land claim has taken place in an area of 780 km<sup>2</sup>, and appears set to rapidly increase in the near future.

In DPRK, coastal land claim has typically focused on agricultural development for rice production, though satellite imagery suggests an increasing focus on urban and industrial land and aquaculture, particularly along the northern parts of DPRK's west coast. Seawalls, ports and dikes have also had an extensive impact on tidal flat ecosystems in DPRK, but many remain in a state of development.

In recent years, aquaculture projects in particular have increased on the West Sea coast of DPRK. Around 15,200 ha was claimed from 2017-2020, equivalent to about 12% of the remaining tidal flats.<sup>69</sup> Commercial satellite data indicates that despite the breaching of sea walls by a tsunami in 1997, there was an increase in the pace of land claims over the last few years. It is estimated that since 2010, about 500 km<sup>2</sup> of land claims have been added across the DPRK coastline. In the future, land claim is set to continue, evidenced by a 2012 speech on land management by Kim Jong Un, noting that the planned area of tidal land claims totals 3,000 km<sup>2</sup>.<sup>70</sup>

#### **5.1.5 Reduced river discharge**

The river flow into the Yellow Sea depression has never been stable. In the coldest periods of the Pleistocene, the Yellow River flowed across the depression to discharge into the Okinawa trench. In historical times, prior to 1855, the Yellow River discharged into the Yellow Sea south of the Shandong Peninsula; after that date, it followed a new course discharging directly into the Bohai Gulf.

---

<sup>68</sup> Yim et al. 2018 ; Murray et al. 2014

<sup>69</sup> Pers. Comm. Alison Beresford, RSPB

<sup>70</sup> Makowsky et al. 2021

More recently, the creation of hundreds of major dams on the rivers flowing into the Yellow Sea, including the Three Gorges Dam on the Yangtze River and the large Sanmenxia dam on the Yellow River of PRC, together with closure and land claims of many estuaries in all three countries, has resulted in a dramatic reduction in the amount of new silt washing into the sea.<sup>71</sup> On the Korean side, three big river-mouth dams (Keum, Youngsan and Daedong) have been built since the 1980s resulting in large reductions in the amount of sediment flow into the sea.

Sediment outflows from the two major rivers flowing into the Yellow Sea, the Yellow River and the Yangtze, have declined by more than 90% and 70% respectively over the last 100 years<sup>72</sup> (Figure 12). Such sediment declines can lead to rapid erosion, subsidence, and ultimately loss in extent of tidal flat ecosystems.<sup>73</sup> The impacts of declining sediment will impact the overall Yellow Sea tidal flats ecosystem; thus, the ecosystem is classified as Endangered under the IUCN Red List of Ecosystems Criterion C on environmental degradation.<sup>74</sup>

The silt that does wash into the sea is now sandier and less muddy than it was 40 years ago.<sup>75</sup> This change in discharge greatly affects the quality of the muddy habitat, reducing productivity,<sup>76</sup> and the distribution, movement and nature of exposed intertidal habitats available for shorebirds and other biota.

The east coast of PRC was characterized by very rapid accretion of the shoreline by as much as a hundred metres per year in some sections. The coast is still accreting in a few sections but is mostly now eroding, especially where the main river channels are cutting back dramatically upstream due to reduced sediment loads.<sup>77</sup> For instance, suspended sediment concentrations at Datong, Yangtze decreased by 56% (from 0.36 to 0.16 g/l) between 1990-1999 and 2000-2020.<sup>78</sup> Seawalls can further change coastal dynamics and result in erosion, for example at Tiaozini, impacting Spoon-billed Sandpiper (*Calidris pygmaea*) habitat.

---

<sup>71</sup> Ren et al. 1986

<sup>72</sup> Syvitski et al. 2009

<sup>73</sup> Syvitski et al. 2022

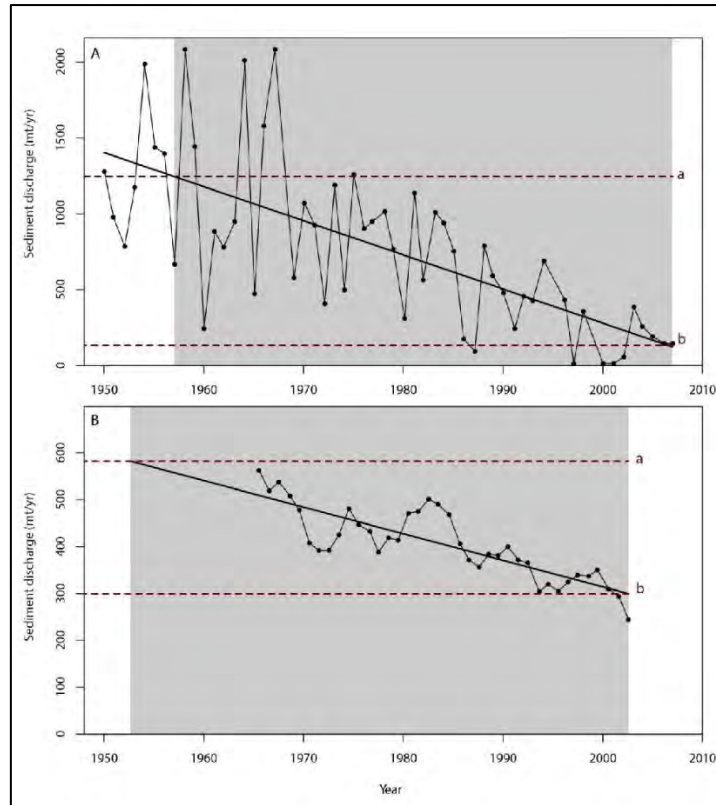
<sup>74</sup> Murray et al. 2015

<sup>75</sup> Ren & Shi. 1986

<sup>76</sup> Wang et al. 2016

<sup>77</sup> Luan et al. 2016 ; Luo et al. 2012

<sup>78</sup> Huang et al. 2022



**Figure 12 Declines of sediment outflow from the Yellow River (A) and Yangtze River (B) (Murray et al. 2015 Data sourced from Yang et al. (2005) and Wang et al. (2010)).**

Grey-shaded areas indicate the 50-yr period used to calculate the relative severity of the sediment decline, as estimated by a least-squares regression model in black, from the initial state, a, to final state, b.

#### 5.1.6 Other coastal developments

There have already been extensive land claims to support expanding urban and industrial areas around the coast of the Yellow Sea.

The Bohai Sea is now considered the most concentrated area of port development worldwide, which has involved extensive coastal land claims<sup>79</sup> and developments (Figure 13). The area of land claimed by the 13 ports in the Bohai Sea in 2002–2018 was 2,300 km<sup>2</sup>, which decreased the area of the sea by 3%. The natural coastline length in Tianjin decreased by 47.5 km, whereas the artificial coastline length increased by 46.6 km.

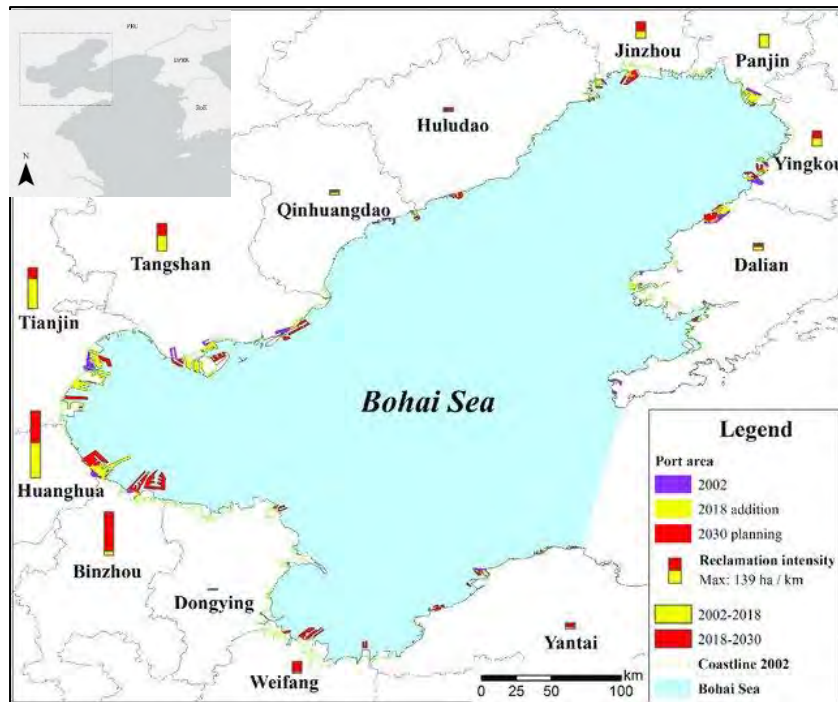
In PRC, urban expansion is forecast to create a 1,800-km coastal urban corridor from Hangzhou to Shenyang<sup>80</sup>. This coastal transformation to an anthropogenic coastline will continue to stress the YSE and lead to irreversible damage to its ecological integrity.<sup>81,82</sup>

<sup>79</sup> Coastal land claim is the process of development into the intertidal area, and is often misleadingly referred to as reclamation in the literature.

<sup>80</sup> Seto et al. 2012

<sup>81</sup> Zhu et al. 2021

<sup>82</sup> Murray et al. 2022



**Figure 13 Future trends of coastal land claim intensity of port clusters in the Bohai Sea. The port land claim will continue to expand, however different ports have different land claim intensity (Zhu et al. 2021).**

#### 5.1.7 Renewable energy farms and other coastal development

Poorly sited and designed wind farms will continue to lead to a decline in the quality of habitats, and the operation of wind turbines will cause direct mortality through collision to migratory birds, especially large flocks and larger birds.<sup>83</sup>

There are many large wind farms along parts of the Jiangsu (Figure 14) and Liaoning coasts. This includes the world's first intertidal wind farm, with 58 turbines and a generating capacity of 150 MW at Rudong, Jiangsu Province, in an area that supports much of the global population of Spoon-billed Sandpiper during both northward and southward migration. This area also supports internationally important populations of 14 additional species of migratory shorebirds.<sup>84</sup>

Two additional intertidal wind farms are planned for Dafeng and Dongtai, both in Jiangsu Province.<sup>85</sup> There is another development planned for the Dongsha Shoals, which is considered an offshore facility, although at least some of the area is likely to be exposed at low tide.<sup>86</sup> As much as 18.5GW of offshore capacity is planned for Jiangsu Province. As of 22 December 2021, the total installed capacity of wind farms off the coast of Jiangsu that are connected to the power grid had exceeded 10 GW.<sup>87</sup>

<sup>83</sup> Xu et al. 2010

<sup>84</sup> Peng et al. 2017

<sup>85</sup> Zhang et al. 2011

<sup>86</sup> Y. Chen & D. S. Melville, unpublished data

<sup>87</sup> Xinhua 2021

The two Jiangsu Rudong 'H6' and the 'H10' offshore wind farms will comprise 100.4 MW wind turbines with rotor diameter of 146m set 70 m above sea-surface level.<sup>88</sup>



**Figure 14 Rudong, Jiangsu offshore wind farm. © Wu Zhenhua**

The potential impact of intertidal wind farms on shorebirds is poorly known, although Dirksen et al. (1998) reported that the height of daily movements of waterbirds in tidal areas in the Netherlands were usually <100m above the ground.

Waterbirds at Rudong could be particularly vulnerable to collisions with turbines at night and in foggy weather. In April, there is an abrupt start to the foggy season in the Yellow Sea,<sup>89</sup> which coincides with the peak of northward migration for many shorebirds.

It is proposed to remove the wind turbines along the landward boundary of Chongming Dongtan NNR, PRC.<sup>90</sup> One reason cited for this is to protect Hooded Cranes (*Grus monacha*) moving from the reserve to forage in harvested rice paddies.

Offshore wind farms are likely to pose a hazard for marine waterbirds and ducks.<sup>91</sup> In the ROK, construction of some of the world's largest offshore wind farms was due to start in 2022, including in the national waters of the Yellow Sea. Most of the sites have not been and will not be surveyed. Instead, as currently proposed, satellite tracking of about 200 individual birds (mostly Black-tailed Gulls (*Larus crassirostris*) and some Black-faced Spoonbills) will be used to map areas of high waterbird value. One proposed site is on or close to the Chilsan Islands in Yeonggwang County, a group of islands with nesting Chinese Crested Terns (*Thalasseus bernsteini*) (CR), Black-faced Spoonbills (EN) and Chinese Egrets (*Egretta eulophotes*) (VU).<sup>92</sup>

---

<sup>88</sup> NS Energy

<sup>89</sup> Zhang et al. 2009; Ding et al. 2011

<sup>90</sup> Li et al. 2020

<sup>91</sup> Ko & Schubert 2011.

<sup>92</sup> Song et al. 2017; 4COffshore 2021



Other forms of power generation that may degrade the suitability of important habitats include plans to harness tidal energy<sup>93</sup> and the construction of large-scale solar energy farms, for example, those under development in the Saemangeum reclamation lake in ROK and many sites in Jiangsu, PRC.<sup>94</sup>

Optimal siting and operation of offshore and coastal wind farms is important to minimise impacts on migratory shorebirds and other waterbirds.

In ROK, the Korea Environment Institute (KEI) will conduct a thorough monitoring process of key species to establish a concrete database regarding their spatial usage in maritime areas. Relevant local research institutes and local experts will support the project to accurately assess the potential impacts on migratory waterbird species.

Research areas will cover intertidal flats (Flyway Network Sites) on the west coast including Yubu island in Seocheon, Aphae Island in Shinan, Hwaseong Maehyang-ri tidal flats and uninhabited islands used by endangered species including in Incheon, Bulmugi island in Shinan, Chilsan island in Yeongkwang, Noru-island in Seocheon. The targeted species for 2022-2023 are the Eurasian Oystercatcher (*Haematopus ostralegus osculans*) (NT), Far Eastern Curlew (*Numenius madagascariensis*) (EN), Eurasian Curlew (*Numenius arquata*) (NT), Bar-tailed Godwit (*Limosa lapponica*) (NT), and Black-tailed Gull (LC).

The project aims to widen the scope of species from 2023 to include bats, raptors and geese. Through this project, ROK will facilitate data exchange through international networks such as the EAAFP Secretariat and share effective assessment approaches for wind farm development in maritime areas of migratory waterbird species.

## 5.2 Over-exploitation

### 5.2.1 Overfishing

The Yellow Sea is highly productive, and constitutes more than 20% of the marine fishery production in PRC. Of about 100 commercial fish species in the Yellow Sea, 66% are demersal (bottom-dwelling) fish, 18% are pelagic fish (swimming in the water column), 7% are cephalopods (octopus and squid), and 7% are crustacea (shrimp and crabs).

With the introduction of bottom trawl vessels in the early twentieth century, many stocks began to be intensively exploited.<sup>95</sup> Stocks remained fairly stable until the 1940s.<sup>96</sup> However, due to a dramatic increase and expansion in fishing effort, nearly all the major stocks were fully fished by the mid-1970s, and the resources in the ecosystem began to be overfished in the 1980s.<sup>97</sup>

Between 1979 and 1999, fish catches in the Yellow Sea grew in parallel with the number of active fishing vessels. Since 1999, catches have declined, despite an increase in the number of active vessels. It has been estimated that the Yellow Sea can no longer support this excess fishing capacity.<sup>98</sup>

---

<sup>93</sup> Byrne 2015

<sup>94</sup> Xinhua 2021

<sup>95</sup> Xia 1960

<sup>96</sup> Tang 2009

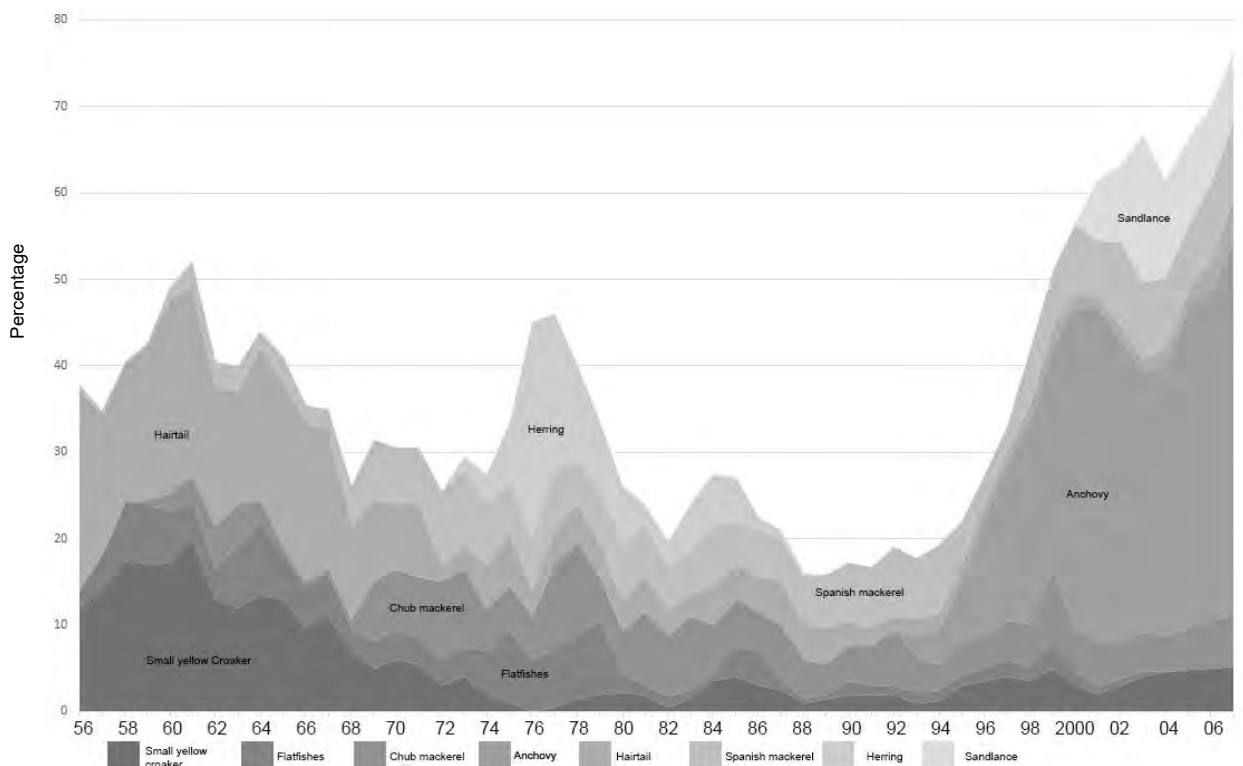
<sup>97</sup> Tang 1989

<sup>98</sup> Ma et al. 2019;

Under the dual pressures of climate variability and overfishing, species catch compositions have markedly changed.<sup>99</sup> In particular, the proportion of warm-water species has increased considerably, while the proportion of cold-water species significantly decreased.<sup>100</sup> Overfishing has also affected the balance between pelagic and demersal species, with some formerly abundant species becoming increasingly rare, and some cold-water species like the Pacific Cod (*Gadus microcephalus*) becoming almost commercially extinct.

In addition, there has been a shift from catching large, valuable, demersal fish at high trophic levels to small pelagic fish at low trophic levels and lower economic value.<sup>101</sup> Continuous intensive fishing has selectively removed larger individuals from higher trophic levels, resulting in a decrease in biomass and the mean body size, as well as changes in species composition.<sup>102</sup>

Prior to 1970, the most commonly caught fish species in the Yellow Sea were Small Yellow Croaker (*Larimichthys polyactis*), Hairtail (*Trichiurus lepturus*) and flatfish. Following the collapse of these stocks, attention switched to Spanish Mackerel (*Scomberomorus niphonius*), Chub Mackerel (*Scomber japonicus*) and Pacific Herring (*Clupea pallasii*). Herring have quickly been exhausted and catch is now mostly Anchovies (*Engraulis japonicus*) and Sandlance (*Ammodytes personatus*) (Figure 15).<sup>103</sup>



**Figure 15 Changes in fish species composition in the Yellow Sea (Redrawn from Zhang 2007).**

<sup>99</sup> Ma et al. 2019b

<sup>100</sup> Liang et al. 2018

<sup>101</sup> Ma et al. 2018

<sup>102</sup> Xu & Jin 2005

<sup>103</sup> UNDP/GEF. 2007

Decline in marine fish capture has led to a rapid expansion of mariculture, negatively impacting natural fisheries. In 2013, aquaculture production in PRC surpassed the amount of offshore fishing for the first time.

The fishery ecosystem function has been predicted to be still declining.<sup>104</sup>

One major cause of the overfishing is poor coordination and cooperation between the three countries. In part this is due to lack of agreement on Exclusive Economic Zones (EEZ) claims in the respective marine areas.<sup>105</sup> DPRK and ROK draw different boundaries around the Baengnyeong-do and other small islands. PRC and ROK developed a provisional map of their respective territorial claims and fishing zones in 2001, but this has been a constant source of contention, with repeat accusations of fishing in each other's waters and even conflict among fishing vessels. Efforts to reconcile viewpoints in 2015 have not been signed.

The fishing industry will face changes in conditions and species compositions. For example, it is predicted that the Japanese Anchovy (*Engraulis japonicas*) will migrate further north.

Innovative technologies to enhance fisheries are currently being tested. As part of the Tangshan Ocean Pasture Project, in Hebei Province, PRC, vessels are dropping pre-fabricated concrete boxes into the Bohai Bay, loaded with micro-organisms intended to anchor algae and thus promote the growth of shellfish and attract fish. The project is driven by local government, partnering with the Tangshan Ocean Ranch Co. and researchers from the Ocean Research Institute at the China Academy of Sciences.

### 5.2.2 *Over-harvesting of intertidal mudflats*

The intertidal mudflats of all three countries have been traditionally harvested for edible molluscs, worms and crustaceans for centuries (Figure 16). In some cases, these traditional practices are continued in a sustainable manner with which waterbirds are able to share the productivity.

In many areas, human population pressure has increased and fishers are using more aggressive harvesting methods, increasing competition with birds for shellfish on the remaining flats. Populations of harvested species are declining, while the level of disturbance to flocks of migrating shorebirds is increasing. Harvesters view shorebirds as an unwanted competition for resources. There is an urgent need to explore options for future management that allow both shorebird foraging and commercial harvesting.

---

<sup>104</sup> Tang et al. 2016

<sup>105</sup> Park 2020



**Figure 16 Traditional cockle harvesting of mudflats in ROK. © World Heritage Promotion Team of Korean Tidal Flats**

### 5.2.3 Mariculture and other aquaculture

Mariculture relates to aquaculture undertaken in seawater. In 2018, 3.6 million tonnes of fish, including molluscs and crustaceans, were produced in ROK, with a value of USD 6,868.9 million. 46% came from aquaculture and 54% was from wild fisheries. Between 2008 and 2018, the quantity produced increased by 8%, while its value increased by 52%.<sup>106</sup> The fishery products produced in 2020 totalled 94,478 tons, valued at KRW 433.1 billion, consisting of 45,745 tons of clams, 33,622 tons of oysters, and 5,923 tons of octopus.<sup>107</sup>

There has been a recent increase in capture fisheries and aquaculture in DPRK including items such as jellyfish and sea cucumbers as export items.<sup>108</sup>

Mariculture production in PRC grew to 13.84 million tonnes in 2005, thereby supplying 73.2 percent of the world's total demand for farmed marine organisms. Around the Yellow Sea, aquaculture is practised both in ponds and in intertidal and subtidal zones. The Bohai Sea accounts for 44% of PRC's total mariculture production, dominated by shellfish and finfish. In 2016, coastal aquaculture production was  $3.5 \times 10^6$  tons. Shellfish, algae, fish, crustacea, and other production accounted for 81.7%, 1.0%, 2.1%, 1.8%, and 3.4% of total aquaculture production, respectively.<sup>109</sup>

Mollusc aquaculture in PRC has resulted in the introduction of species outside their native range and a homogenisation of soft-shore communities.<sup>110</sup>

---

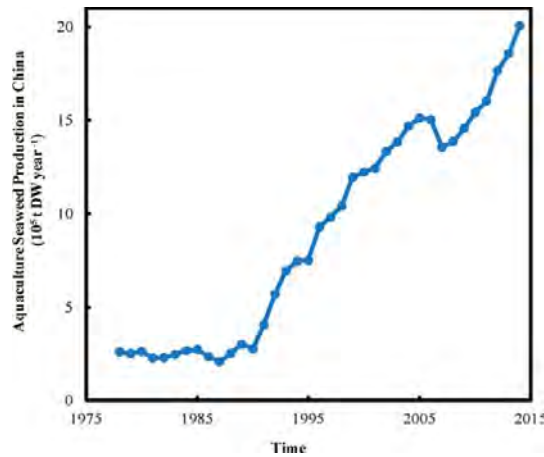
<sup>106</sup> OECD. 2021

<sup>107</sup> Ministry of Oceans and Fisheries 2021

<sup>108</sup> Jin & Yoon 2021

<sup>109</sup> Song & Duan 2019

<sup>110</sup> Peng et al. 2021



**Figure 17 Rise in aquaculture production in PRC (Xiao et al. 2017. Data from China Fishery Statistical Yearbook from 1979 to 2015).**

Increased concentrations of nutrients from the decomposition of food material for aquacultured organisms has led to marine pollution and associated changes in the turbidity and pH of seawater, further altering microorganism abundance and levels of dissolved oxygen.

Mariculture/aquaculture also increases 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.

The current level of seeding of *Macra*, a type of clam, at Yalujiang is such that if there was no bird predation, growth rates of the clams would likely be very slow due to overcrowding and competition. Despite this, fishers are very unhappy to see huge flocks of birds eating the clams.

Approximately two-thirds of the global production of commercial seaweeds comes from PRC. Seaweed production is a large and growing component of mariculture in the region and globally (Figure 17). The harvesting of seaweed can also remove excess phosphorus from the ecosystem, however, it is still unable to address the excess nitrogen levels that lead to eutrophication.<sup>111</sup> ROK is the biggest consumer of marine algae in the world and Koreans eat more than 50 species of such seaweeds.<sup>112</sup>

### 5.3 Pollution

High levels of pollution across the Yellow Sea have had a clear negative impact on fisheries, wildlife and human health. Four main types of pollution are recognized:

#### 5.3.1 Plastic waste

Marine microplastics are a global problem and a growing concern. As the largest marginal sea of the Western Pacific, the Yellow Sea coastal ecosystem is greatly affected by human activities. One study along the Yellow Sea coasts of PRC collected data on surface water, the seawater column, sediments, and marine organisms.<sup>113</sup> The results indicated that plastic

<sup>111</sup> Xiao et al. 2017

<sup>112</sup> Hwang et al. 2010

<sup>113</sup> Li & Sun 2020

debris exists throughout the west Yellow Sea, with a higher abundance of microplastics in water columns and sediments in the northern part than in the southern part. Fibres <1 mm and transparent-coloured particles dominated the samples collected. Polyethylene, polypropylene, and cellophane were the dominant debris types. The wide distribution of microplastics in the environment results in animal ingestion. The review demonstrates that actions should be taken to reduce the consumption and release of plastics into the environment.

Shorebirds have a high potential to be exposed to and ingest plastics pollution, as many species migrate long distances and periodically concentrate around shorelines, coastal areas, and estuaries that can have elevated levels of plastics pollution.

A review by Flemming et al.<sup>114</sup> catalogued and reviewed available studies across the globe that examined plastics pollution in shorebirds and quantified relevant traits of species and their environments to explore how shorebirds may be exposed to plastics pollution. Of 1106 samples from 26 shorebird species described within 16 studies that examined plastic ingestion, 53% of individuals contained some form of plastics pollution. Plastics frequency of occurrence (FO) was much greater among species that migrated across marine areas (either oceanic or coastal) than those species that used continental flyways. Species that foraged at sea, on mudflats, or on beaches had higher average FO of plastic ingestion than species that foraged in upland or freshwater environments. Finally, species that used a sweeping foraging mode showed higher levels of ingested plastics and contained a far greater number of plastic pieces than all other techniques. These conclusions are based on a limited number of species and samples, with the distribution of samples skewed taxonomically and geographically.

### 5.3.2 *Eutrophication and algal blooms*

Pollutants from municipal, industrial and agricultural waste and run-off, as well as atmospheric deposition, are “fertilizing” coastal areas, triggering harmful algal blooms and creating oxygen deficient “dead zones” in the Yellow Sea. The algal blooms and associated low levels of dissolved oxygen in the water make it difficult for fish, benthic fauna and other marine life to survive, impacting the sustainability of related social and economic activities.

Since the 1970s, the annual mean water temperature and dissolved nitrogen in the sea increased by 1.7°C and 2.95  $\mu\text{mol L}^{-1}$ , respectively, while those of dissolved oxygen, phosphorus, and silicon decreased by 59.1, 0.1 and 4.93  $\mu\text{mol L}^{-1}$ , respectively.<sup>115</sup>

A direct result of eutrophication is an increase in marine macroalgae blooms in the intertidal zone. Over the past decade, macroalgal blooms have increased worldwide in frequency and size.<sup>116</sup>

Harmful algal blooms (HABs) manifest themselves in the Yellow Sea in several ways. Green tides are typically blooms of the algae *Ulva* or *Enteromorpha*. Red tides are generally blooms of dinoflagellate algae. Golden tides are typically blooms of the brown macro-algae *Sargassum*. The impacts of HABs include depletion of dissolved oxygen, release of toxins that cause health risks to marine organisms and humans, and interference with seaweed farming

---

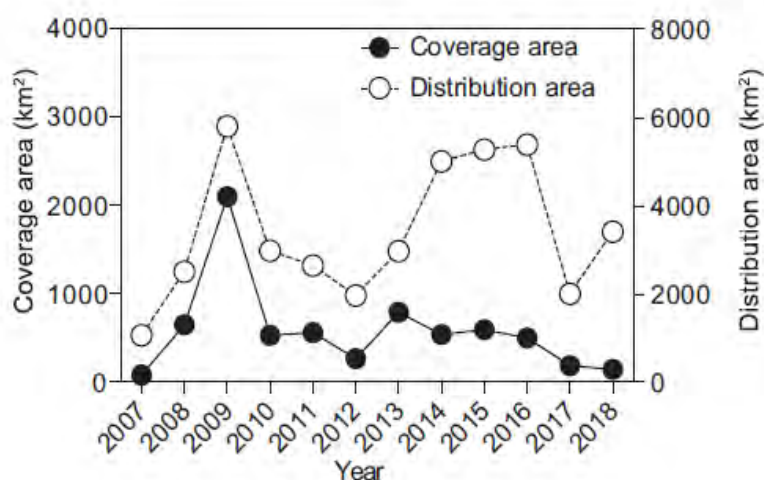
<sup>114</sup> Flemming et al. 2022

<sup>115</sup> Lin et al. 2005

<sup>116</sup> Ye et al. 2011

operations. In 2006, red tides led to a mass fish die-off of 12 million fish, leading to safety warnings in Shanghai about eating seafood from the affected area. Such HABs can be triggered by anthropomorphic eutrophication and imbalances in nutrient ratios.<sup>117</sup>

Since 2007, during spring (March-May), macroalgal blooms have initially occurred along the Jiangsu coast with small-scale floating algae, then migrated northward along the coast of the southern Yellow Sea driven by sea currents, accumulating in the nearshore waters of the Shandong Peninsula in summer, and then declining gradually.<sup>118</sup> With an annual coverage area of over 20,000 km<sup>2</sup>, *Ulva prolifera* bloom in the Yellow Sea is the largest green tide in the world so far (Figure 18).<sup>119</sup> The worst event was in 2008 around Qingdao port, and the direct economic losses caused by that macroalgal bloom were as high as 1.3 billion RMB (US \$180 million).<sup>120</sup>



**Figure 18 Variation in the distribution and coverage areas of the *Ulva prolifera* green tides from 2007 to 2018 (Zhang et al. 2015).**

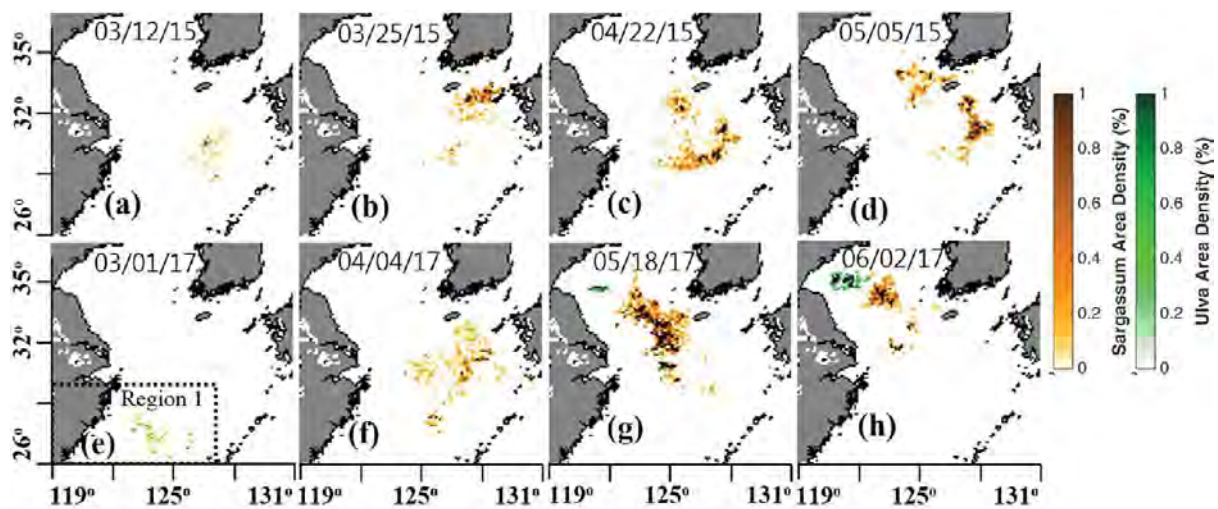
Such massive macroalgal blooms in the Yellow Sea have a negative impact on the coastal environment, upsetting the balance of coastal ecosystems, affecting air–sea exchanges and even causing the death of cultured organisms, such as sea cucumbers and shellfish.<sup>121</sup> During the late development stage of green tides, the decomposition can degrade seawater quality and cause foul odours, interfering with local tourism and coastal mariculture in the Shandong Peninsula. In addition, such massive macroalgal blooms can have a long-term impact on marine biogeochemical cycles.<sup>122</sup>

The Yellow Sea experiences not only the world’s largest green tides,<sup>123</sup> but also golden tides.<sup>124</sup> First reported in 2000, these caused little concern because they drifted into the open sea without damaging coastal areas. However, in 2015 (Figure 19), *Sargassum* golden tides

<sup>117</sup> UNDP. 2020  
<sup>118</sup> Zhou et al. ,2015  
<sup>119</sup> Liu et al. 2013  
<sup>120</sup> Ye et al. 2011  
<sup>121</sup> Zhang et al. 2015  
<sup>122</sup> Zhang et al. 2019a  
<sup>123</sup> Qi et al 2016  
<sup>124</sup> Zhang et al. 2019a

occurred in Shinan-gun and Jeju Island of ROK. During this bloom, 5,180 tonnes of *Sargassum* were removed from 3,339 ha of the coastline, while 20,000 tonnes were removed from Jeju Island. The huge floating masses of seaweed caused severe damage to fisheries in Shinan-gun, including abalone sea cages, and *Pyropia yezoensis* and *Saccharina japonica* farms off the southwest coast of ROK.

In 2017, *Sargassum* blooms covered up to 188 km<sup>2</sup> and drifted into the offshore region of Jiangsu Province, which is the traditional area for *Pyropia yezoensis* aquaculture in PRC. It led to poor growth and low or no yield of *P. yezoensis* in more than 9,000 ha of aquaculture, resulting in direct economic losses of 6.7 billion US dollars.<sup>125</sup> In January 2020, *Sargassum* blooms again negatively impacted *P. yezoensis* aquaculture in PRC, indicating that golden tides have become a new threat to the marine ecology and environment. Previous studies suggested that the source material responsible for golden tides in the Yellow Sea may have come from the Zhejiang coast in the East China Sea.<sup>126</sup>



**Figure 19 Northward drifting of *Sargassum* in 2015 and 2017 (Qi et al. 2017).**

Yellow to brown colours represent the floating *Sargassum*, while green indicates floating *Ulva*.

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 from *Sargassum* in PRC, with estimated losses of 500 million CNY (about USD \$73 million).<sup>127</sup>

### 5.3.3 Oil discharge from ships and pipelines

The Bohai Sea overlies three oil fields: Liaohe, in Liaoning Province; Shengli, in Tianjin Municipality and Hebei and Shandong Provinces; and Penglai, offshore in the central Bohai Sea. Shengli is PRC's second largest oil-field, and produces approximately 650,000 barrels per day.<sup>128</sup>

<sup>125</sup> Zhuang et al. 2021

<sup>126</sup> Xing et al. 2017; Zhang et al. 2019a

<sup>127</sup> Xing et al. 2017

<sup>128</sup> Shengli Oil Field Fact Sheet



Oil extraction occurs on land, in the intertidal zone and offshore. PRC is also the world's largest importer of oil, and large new refineries are being developed in Bohai Bay at Caofeidian and Tangshan in Hebei Province. There are seven high-risk zones for oil spills in the Bohai Sea,<sup>129</sup> including the sea south of Nanpu, Hebei Province, which is the main staging site for Red Knots (*Calidris canutus*) in the Yellow Sea.

Oil is frequently discharged into the sea from ships when the bilges are pumped, however a much greater threat is the risk of leaks from large oil tankers or damage to oil well infrastructure. In April 2021, the A Symphony, a Suezmax tanker, capable of carrying about one million barrels of crude oil, was struck by a bulk carrier at an anchorage site off Qingdao port in the Yellow Sea, causing it to spill about 400 tonnes.<sup>130</sup> The spill threatened operations at Qingdao port in Shandong province, the biggest crude-receiving terminal in PRC, and a hub for oil refiners that accounts for about a quarter of PRC's total processing capacity.

A large oil spill also occurred on 16 July 2010, which was caused by a rupture and subsequent explosion of two crude oil pipelines that run to an oil storage depot of the China National Petroleum Corporation in Xingang Harbour, Dalian. Approximately 1,500 tonnes of oil spilled from the pipes, creating a 180 km<sup>2</sup> slick in the Yellow Sea that grew to 430 km<sup>2</sup> within a week. By July 21, the spill had spread to 946 km<sup>2</sup>, and stretched as far as 90 km along the coast. Tourism was affected after oil began washing ashore on beaches, some of which were closed after the spill. The oil also severely affected the fishing industry near Dalian, particularly offshore shellfish farms. The economic loss was estimated to be as high as tens of millions US dollars. Wildlife inhabiting the area was exposed to oil, which led to the deaths of some, with longer-term effects to others.<sup>131</sup>

Such spills seriously affect seabirds, and can take months, or years, to clean up, with long lasting impacts on the area's ecosystem as well the livelihoods of people who depend on the sea.

#### 5.3.4 Toxic chemicals (DDT, PCB and PAH)

Many recent publications document the presence of toxic chemicals in the Yellow Sea.<sup>132</sup> Red-throated Loon populations that migrate from breeding grounds to the Yellow Sea have higher chemical levels, leading to lower breeding success in Alaska, compared to populations breeding there that migrate within the Americas.<sup>133</sup>

The principal chemicals identified as a risk to the Yellow Sea ecosystem include:

- **Organochlorine pesticides:** Dichlorodiphenyltrichloroethane (DDT) is still a commonly used pesticide in PRC. By 2003 an estimated 250 tonnes of DDT was used annually in the anti-fouling paint applied to fishing vessels in PRC.<sup>134</sup> This paint is known to contaminate ocean sediment and impact marine biodiversity, affecting the lives of local fisherman as well as consumers. While DDT use in boat paint ceased in

---

<sup>129</sup> Liu et al. 2015

<sup>130</sup> Cang & Koh 2021

<sup>131</sup> Greenpeace 2010

<sup>132</sup> Byun et al.2013; Grung et al. 2015; Li et al. 2015; Li et al. 2021; Wang, G. et al. 2015; Wang, R. et al. 2015; Wang et al. 2016; Xiao et al. 2017; Zhang et al. 2020

<sup>133</sup> Schmutz et al. 2009; McCloskey et al. 2018

<sup>134</sup> UNDP 2014

2009, it continues to be used in agriculture, and the chemical has a long persistence in biota and sediments. Being lipophilic, DDT may accumulate in waterbirds, especially mollusc feeders such as the Red Knot, which stores fat prior to migrating.

For DDT and Hexachlorocyclohexane (HCH), the most relevant matrix for environmental risk assessment is biota. The concentrations in biota reveal that a majority of the results from the studies in Bohai and Yellow Seas are classified as “very bad” for DDT. The risk for biota is much lower for HCH, for which the majority of the levels in biota can be classified as Class I or II (background or good).<sup>135</sup>

- **Polycyclic aromatic hydrocarbons (PAHs)** are a group of ubiquitous persistent organic pollutants that are generally formed by incomplete combustion of fossil fuels and biomass.<sup>136</sup> Due to their low water solubility, low volatility, and high persistence, PAHs in water systems tend to accumulate in sediments, and have a long-term impact on benthic organisms.<sup>137</sup>

Such chemicals accumulate in the Yellow Sea ecosystem from coal combustion, vehicular emissions and coke production. PAHs can be bio-accumulated through the food chain, and the exposure of humans to PAHs may enhance the risk of cancer and other adverse health effects.<sup>138</sup> Ma et al. (2001) reported the distribution of PAHs in sediments from the intertidal zone of the Bohai Sea and Yellow Sea.

- **Heavy metals** are a serious pollutant to the Bohai Sea.<sup>139</sup> Annual discharges of mercury, cadmium, lead, and arsenic from 13 coastal cities in this area are estimated to be 30, 400, 1,400, and 2,000 tonnes per year, respectively, into Bohai Sea.<sup>140</sup>
- Pollution from **inorganic nitrogen and phosphorous, oil, and heavy metals** has led to a sharp decline in fishery resources, decreasing the food supply available to both migratory shorebirds and people.<sup>141</sup>
- **Antibiotics** are another pollutant that have a wide range of impacts on lower and higher animals. A wide range of antibiotics flow into the Yellow Sea ecosystem from terrestrial livestock farming, urban wastewater and aquaculture facilities<sup>142</sup>.

#### 5.4 Invasive alien species

Many non-native marine species, including fishes, molluscs, algae, crustaceans and ascidians, have been deliberately introduced into PRC's marine ecosystems for aquaculture<sup>143</sup> or other purposes such as mudflat stabilisation. In addition, accidental introductions occur

---

<sup>135</sup> Grung et al. 2015

<sup>136</sup> Arias et al. 2010

<sup>137</sup> Liu et al. 2013

<sup>138</sup> Grung et al. 2015

<sup>139</sup> Yu et al. 2022

<sup>140</sup> Liang et al. 2018

<sup>141</sup> Tang et al. 2015

<sup>142</sup> Chen & Zhou 2014 ; Du et al 2017, 2019 ; Han et al 2021 ; Lu et al 2019 ; Na et al. 2013 ; Shi et al.2014 ; Xie et al 2019 ; Zhang et al 2013a, 2013b

<sup>143</sup> Lin et al. 2015

through a variety of vectors, including ship ballast water and the escape of non-native species from farms.<sup>144</sup>

Recent research indicates that non-native aquatic organisms cause significant ecological and economic problems in PRC.<sup>145</sup> The Yellow Sea had the highest number of non-native marine species (86 species), followed by the Bohai Sea (72 species), the East China Sea (57 species), and the South China Sea (36 species). There are 93 non-native marine species that have been shown to have negative impacts on PRC's marine ecosystems. About one-third of all non-native marine species introduced into PRC have established feral populations.<sup>146</sup>

There are a wide range of impacts on a diversity of species. As just one example, breeding seabirds on some islands in the YSE are negatively affected by invasive alien species, including *Rattus norvegicus* predated the eggs of Streaked Shearwater, and the infestation of *Achyranthes japonica*, a prickly plant that blocks the nesting burrows of Swinhoe's Storm-petrels, and traps adults and young.<sup>147</sup>

#### 5.4.1 *Spartina cordgrass*

The most widely discussed coastal invasive problem affecting the Yellow Sea coast is the invasive alien Smooth Cordgrass *Spartina alterniflora*. Since its introduction on the coasts of Jiangsu, Fujian and Hangzhou Bay in the 1980s, the plant has occupied many new areas. It is now widespread along the entire Jiangsu coast, around the Yangtze estuary in Shanghai, and Bohai Bay in Shandong, Tianjin and Hebei, covering an area of 77,892 ha by 2014.<sup>148</sup> Where it occurs, *Spartina alterniflora* has changed the pattern of macrobenthos community distribution; accelerated the process of land cover formation; and can form a two-meter tall "green barrier" between the waterbirds and their food.<sup>149</sup>

Wang (1983) noted that the zone of native *Suaeda* flats on the northern Jiangsu coast was 4–5 km wide. In 1993, outside the seawall at Yancheng, there was still at least 1 km of *Suaeda* flat that extended to the unvegetated tidal flats.<sup>150</sup> Some *Suaeda* flats remain, but they are separated from the tidal flats by several kilometres of *Spartina alterniflora*.<sup>151</sup>

Monitoring changes in wetland habitats and waterbird communities between the 1980s and 2000s at Chongming Dongtan revealed a net loss of 11% of the intertidal wetland area, much of it caused by the expansion of *Spartina alterniflora*. The area of artificial habitats such as paddy fields and aquaculture ponds more than doubled, and more than 65% of natural habitats, including *Scirpus mariqueter* and *Phragmites australis* marshes, but the alien *Spartina alterniflora* spread to 30% of the vegetated intertidal zone.

A large *Spartina* eradication project at Chongming Dongtan NNR, Shanghai has impounded ~25 km<sup>2</sup> of *Spartina* marsh with a seawall and the plants were killed by cutting and flooding. However, it was not possible to re-establish tidal flats as the sediment elevation is now too

---

<sup>144</sup> Liang & Wang 2001; Zhao et al. 2006

<sup>145</sup> Lin et al. 2005; Xu et al. 2006

<sup>146</sup> Xiong et al. 2017

<sup>147</sup> Lee 2010

<sup>148</sup> Gao et al. 2014

<sup>149</sup> Ren et al. 2021

<sup>150</sup> D. S. Melville, personal observation

<sup>151</sup> Zhang et al. 2011

high, and so the area is being managed as a non-tidal brackish wetland. Trials using the grass-selective herbicide Haloxypop-R-methyl have been encouraging, with high rates of loss of *Spartina* and no significant effects on meiofauna.<sup>152</sup> Field trials with the broad-spectrum herbicide Imazapyr have also been successful.<sup>153</sup> Drones are now used at Chongming Dongtan and elsewhere to spray intertidal flats.

It is important to prevent *Spartina* from damaging the remaining tidal flats, especially in DPRK, if these are to remain accessible to shorebirds and other waterbirds. Eradication in the Bohai Sea is likely achievable by ground spraying, whereas in Jiangsu Province, aerial spraying will be required owing to the very large areas. However, current land claims in Jiangsu Province mean that in coastal areas, *Spartina* is now absent, with seawalls having been extended beyond the immersion depth that the plant will tolerate.

In February 2023 China launched the Special Action Plan for the Prevention and Control of *Spartina* (2022-2025), a national programme to eradicate 90% of *Spartina* by 2025. All coastal provinces had to submit to the National Forest and Grassland Administration their proposals for *Spartina* eradication by 28 February 2023<sup>154</sup>. The University of Cambridge, with the World Coastal Forum Task Team on Science and Evidence, undertook a global review of evidence on different methods of *Spartina* invasive management to support this important effort.<sup>155</sup>

In 2016, *Spartina* species were designated as “Invasive Alien Species” under the Wildlife Protection Act in ROK. *Spartina* is not yet widespread on the Korean Peninsula, but reports of it are increasing.<sup>156</sup> *Spartina* has partially invaded the Ganghwa area, ROK near the DPRK border. The ROK government is currently restraining the expansion of *Spartina* through removal projects and is conducting monitoring projects with local residents. Such control currently relies upon physical removal; the widespread use of herbicides as used in PRC has been rejected due to fears that it may have negative impacts on the harvesting of sea algae.

#### 5.4.2 Alien fishery species entering YSE

Many fisheries species have been added to the YSE: 26 such fish species are listed, in addition to a number of crustaceans, molluscs and economically farmed algae.<sup>157</sup> Some species such as eels (*Anguilla anguilla* and *Anguilla rostrata*), Spotted Seatrout (*Cynoscion nebulosus*), Red Drum (*Sciaenops ocellatus*), and American Shad (*Alosa sapidissima*), have added to economic opportunities, but many have had negative impacts by out-competing native biota, impacting the genetic makeup of native populations (e.g. in abalones) or bringing in new diseases or parasites.

One example is the *Lymphocystis* virus (LCV), which is often discovered in the flatfish of Europe and America. Following the introduction of flatfish to PRC, this pathogen spread rapidly throughout some important culture regions of Shandong Province, PRC, leading to the death of more than 60% of native flounders.<sup>158</sup>

---

<sup>152</sup> Zhao et al. 2020

<sup>153</sup> Peng et al. 2022

<sup>154</sup> Gan 2023

<sup>155</sup> Reynolds et al. 2023

<sup>156</sup> Kim 2017

<sup>157</sup> Xiong et al. 2017

<sup>158</sup> Qu et al. 1999; Hu et al. 2021

The Korean Marine Environment Management Corporation (KOEM) has been removing polyps of Moon Jellyfish (*Aurelia aurita*) since 2013, to inhibit their mass proliferation which can be harmful to fisheries when caught in nets. This native species has expanded its range from Japan into the Yellow Sea, apparently due to climate change.

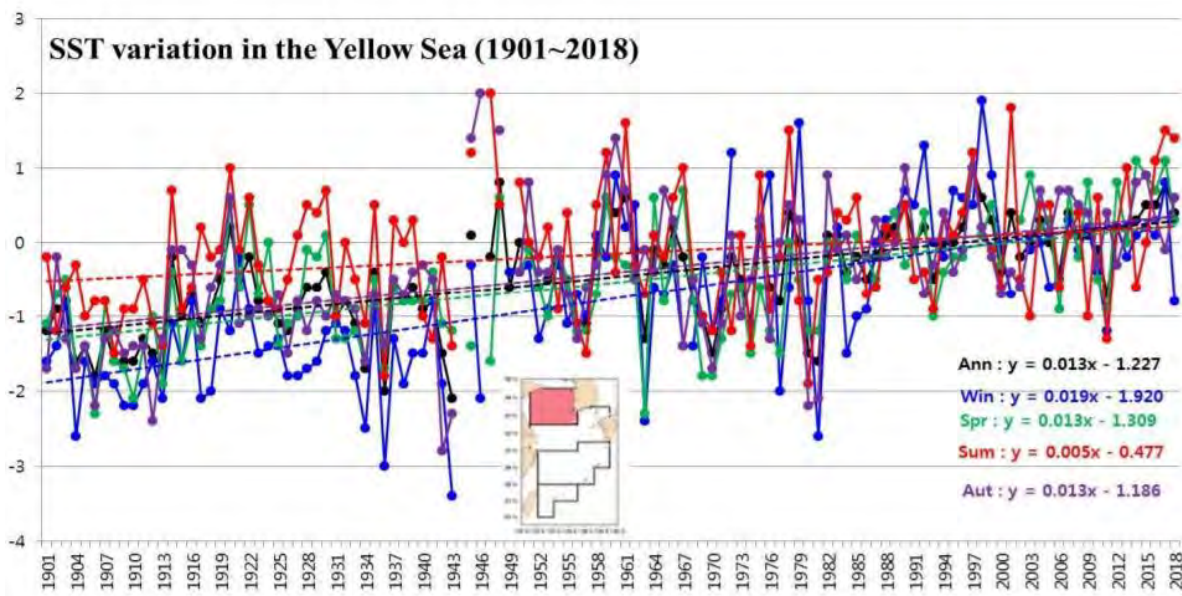
## 5.5 Climate change

Climate change and the increasing severity of its impacts, is emerging as the largest threat to the health of the Yellow Sea Ecosystem.

The IPCC has published its latest and most alarming reviews of climate change and future scenarios, which indicate that sea level, ocean pH, sea surface and deep water temperatures will all continue to rise in the future.<sup>159</sup> Severe weather events are also expected to continue to increase in severity and frequency.

Depending on the measures that the global community is able to implement to reduce CO<sub>2</sub> levels in the atmosphere, temperature is still expected to rise towards 3°C above pre-industrial levels by the end of the century, with worst case scenarios projecting towards 5°C.

Although individual years may be warmer or cooler as a result of several oceanic oscillations (Arctic Oscillation, Pacific Decadal Oscillation and the Siberian High), the long-term trend for over a century is sea surface warming in the Yellow Sea (Figure 20). It has been warming at a rate of 1.2°C per century, which is more than twice the global average rate. The rising temperature is more pronounced in winter.<sup>160</sup>



**Figure 20** Sea Surface Temperature variation through 20th century; seasonal patterns shown separately for shaded region on inset map (Han & Lee 2020).

<sup>159</sup> IPCC 2022

<sup>160</sup> Han & Lee 2020

Since 2020, periodic marine heatwaves have increasingly occurred around the Korean Peninsula during summertime. They have a serious impact on fisheries and cause mass mortalities in aquaculture.<sup>161</sup> Unusually cold periods have also been recorded.

In the Yellow Sea, rising sea-surface temperatures, rising sea levels and ocean acidification are likely to cause a wide range of impacts, including increasing occurrences of HABs, alterations of trophic structures and species balance, such as northward distributions of warm water species, for example modelling studies conducted by PRC predict a northward movement in the economically important Japanese Anchovy over the next three decades.<sup>162</sup>

### 5.5.1 Storm activity

Storm driven tides in the Yellow Sea mainly occur in summer and autumn, due to the influence of tropical cyclones. Tropical storm surges often devastate the highly populated coastal regions in south Yellow Sea, which have caused serious economic loss and human injury in previous decades.<sup>163</sup> From 2000–2015, there were 17 storms on the coast of Jiangsu Province and Shanghai city and 16 storms on the coasts of the Shandong and Liaodong Peninsulas.<sup>164</sup> In 2015, direct economic losses caused by storms in Shandong and Jiangsu Provinces totalled 0.44 billion RMB yuan (US\$ 69 million) and 0.58 billion RMB yuan (US\$ 91 million), respectively.

While typhoons directly damage wildlife, vegetation and can erode mud banks, they can also have some positive effect on intertidal habitats. One or two typhoons in a decade can be strong enough to erode between 10-30 cm of the upper layer of the tidal flats, redistributing a significant amount of sediment and promoting natural coastal processes.<sup>165</sup> This plays a crucial role in maintaining the overall health of the sedimentary system and associated habitats.<sup>166</sup>

While the annual occurrence frequency of typhoons in the western North Pacific has gradually decreased, their frequency affecting the Korean Peninsula has increased and the spatial pattern has migrated northward. This coincides with the increase in air temperature and sea surface temperature around the Korean Peninsula.

### 5.5.2 Sea pH

As CO<sub>2</sub> levels increase in the atmosphere, dissolved CO<sub>2</sub> in rainwater will create a more acidic sea. This will be a critical factor for many intertidal and marine organisms and lead to new impacts on the health of the Yellow Sea Ecosystem, as calcium levels are critical for the formation of mollusc shells and many other biotic structures. A number of changes that are attributable to raised acidity have already been documented and more dramatic changes are expected in the future.

---

<sup>161</sup> KMA 2019

<sup>162</sup> Liu et al. 2020.

<sup>163</sup> Jinshan et al. 2020

<sup>164</sup> SOAC 2000–2015

<sup>165</sup> Chun et al. 2004

<sup>166</sup> Getbol WH Nomination. 2020 p.58

### 5.5.3 Sea level

Global sea level is expected to rise approximately 0.5 m by the end of the century with worst case scenarios projecting more than one metre of rise by 2100.<sup>167</sup>

PRC alone accounts for 15–28% of global extreme coastal water level (ECWL) exposure across digital elevation models (DEMs), depending upon the scenario, but Coastal DEM increases absolute estimates for PRC by a factor of roughly three compared to modelling using the Shuttle Radar Topography Mission.

Under scenario K14/RCP4.5, PRC could see land now home to a total of 43 (29–64) million people below Mean Higher High Water MHHW by end of the century, or 57 (30–100) million in the case of Antarctic instability (K17/RCP 4.5). The average marginal increases in exposure from baseline are 20 (range 6–41) million and 34 (range 7–77 million), respectively.

In the Yellow Sea, sea level rise and local land subsidence will lead to relative sea level rise that is expected to be considerably higher than sea level rise alone and likely more than 1 metre by 2100. This is expected to result in very large areas of coastal plains becoming increasingly prone to flooding,<sup>168</sup> especially in Jiangsu province of PRC. Sediment compaction due to natural and anthropogenic factors, and local land subsidence caused by ongoing extraction of freshwater and fossil fuels, will exacerbate the region-wide impacts of changing sea levels and may lead to an elevated risk of damage to extensive coastal infrastructure along the Yellow Sea coastline.<sup>169</sup>

For example, one study modelled the effects on PRC's eastern coast of a rise in sea level resulting from climate change, considering natural tectonic ground movement, as well as land subsidence which may be exacerbated by ground water and oil extraction, and construction of large buildings. The study predicts that with a 100-year flood water level there could be massive inundation, including inundation of 5,000 km<sup>2</sup> around Bohai Bay and of 64,100 km<sup>2</sup> in the Yangtze River Delta–Jiangsu area in 2080.<sup>170</sup>

While there are no large-scale spatial models that have a proven ability to forecast the likely future extent of tidal flats in the Yellow Sea for different sea level rise scenarios, global scale simulations suggest that a key determinant of future tidal wetland extent is the availability of space that coastal wetlands can retreat into and keep pace with rising sea level.<sup>171</sup> This 'accommodation space' enables wetlands to accumulate sediment in formerly terrestrial areas, reducing the severe impact that sea level rise is expected to have on tidal wetlands.

However, the Yellow Sea region is among the most developed coastlines on Earth, and there are few areas where there is any accommodation space that could allow tidal flat ecosystems to persist with rising sea levels. If sediment supply is sufficient, tidal flats may continue to gain elevation and occur on the seaward edge of coastal reclamations, but remote-sensing observations over the last few decades suggest that tidal wetland gains are always outpaced by loss.

---

<sup>167</sup> Kirezci et al. 2020; Edmonds et al. 2020; Spalding et al. 2014; Kulp & Strauss 2019

<sup>168</sup> Hooijer & Vernimmen. 2021

<sup>169</sup> Higgins et al. 2013

<sup>170</sup> Zuo et al. 2013

<sup>171</sup> Schuerch et al. 2018

Therefore, although some simulations suggest tidal wetlands may keep pace with sea level rise in some areas of Earth, a one metre rise in sea level in the Yellow Sea will more likely lead to extensive areas of tidal wetlands being inundated, putting billions of dollars of coastal infrastructure at risk. Combined with an increased risk of more severe storm surges as a result of reduced natural coastal defences, there is a high likelihood of severe impacts of sea level rise on the Yellow Sea. If sea walls are constructed as a solution for protecting coastal infrastructure, the impact on tidal flats may be even greater.

Therefore, it is imperative that future coastal planning considers restoring and extending the nature-based coastal defence afforded by coastal tidal flats. For example, consider undertaking managed realignments building on pilot projects such as at Seocheon Tidal Flats, ROK which follows the methodology from the Wadden Sea.

## 5.6 Zoonotic diseases and other threats

The proximity of intensive poultry farming near the migratory pathways of wild birds is a recipe for disease outbreaks in both directions.<sup>172</sup> Such poultry farms can be found throughout the EAAF, and are not confined to the three Yellow Sea countries. There have been continuing outbreaks of multiple strains of Highly Pathogenic Avian Influenza (HPAI) in the region<sup>173</sup> and these can have serious effects on domestic poultry and impacts on key migratory bird populations such as the Black-faced Spoonbill,<sup>174</sup> as well as the economy and human health.

There is growing evidence of shorebirds in the EAAF being exposed to HPAI,<sup>175</sup> and recently there have been major mortality events among shorebirds such as the Red Knot in Europe.<sup>176</sup> A recent example from Israel in late 2021 saw more than 5,200 Common Cranes (*Grus grus*) die of HPAI at their wintering area at Hula Lake Reserve. Local farmers were asked to slaughter 500,000 poultry in an effort to contain the epidemic.<sup>177</sup> Data on the occurrence of HPAI in wild birds is collected by national authorities but much remains unpublished, making it difficult to determine the severity of the problem.

Avian botulism is a bacterial disease in migratory birds worldwide, and can affect millions of birds. From 2002–2003, an outbreak in Taiwan, PRC killed more than 7% of the global population of Black-faced Spoonbills.<sup>178</sup> The first reported outbreak of type C botulism in ROK occurred in October 2007 in the Tan-cheon, a small branch of the Hangang River. In October 2008, approximately 2,000 birds (mainly ducks, especially spot-billed ducks, and a few Black-faced Spoonbills) died from type C botulism in the Namdong reservoir in Incheon. Other outbreaks have subsequently occurred in Namdong reservoir.<sup>179</sup>

In addition to bird diseases, the Yellow Sea ecosystem hosts a number of aquatic diseases that have serious impacts on wild caught fisheries and mariculture. Unhygienic mariculture can contribute to the spread of these diseases. One study that summarized the overall effects

---

<sup>172</sup> Muzaffar et al. 2010; Prosser et al. 2013

<sup>173</sup> Melville & Shortridge 2006

<sup>174</sup> FAO 2022

<sup>175</sup> Wille et al. 2019

<sup>176</sup> EFSA et al. 2021

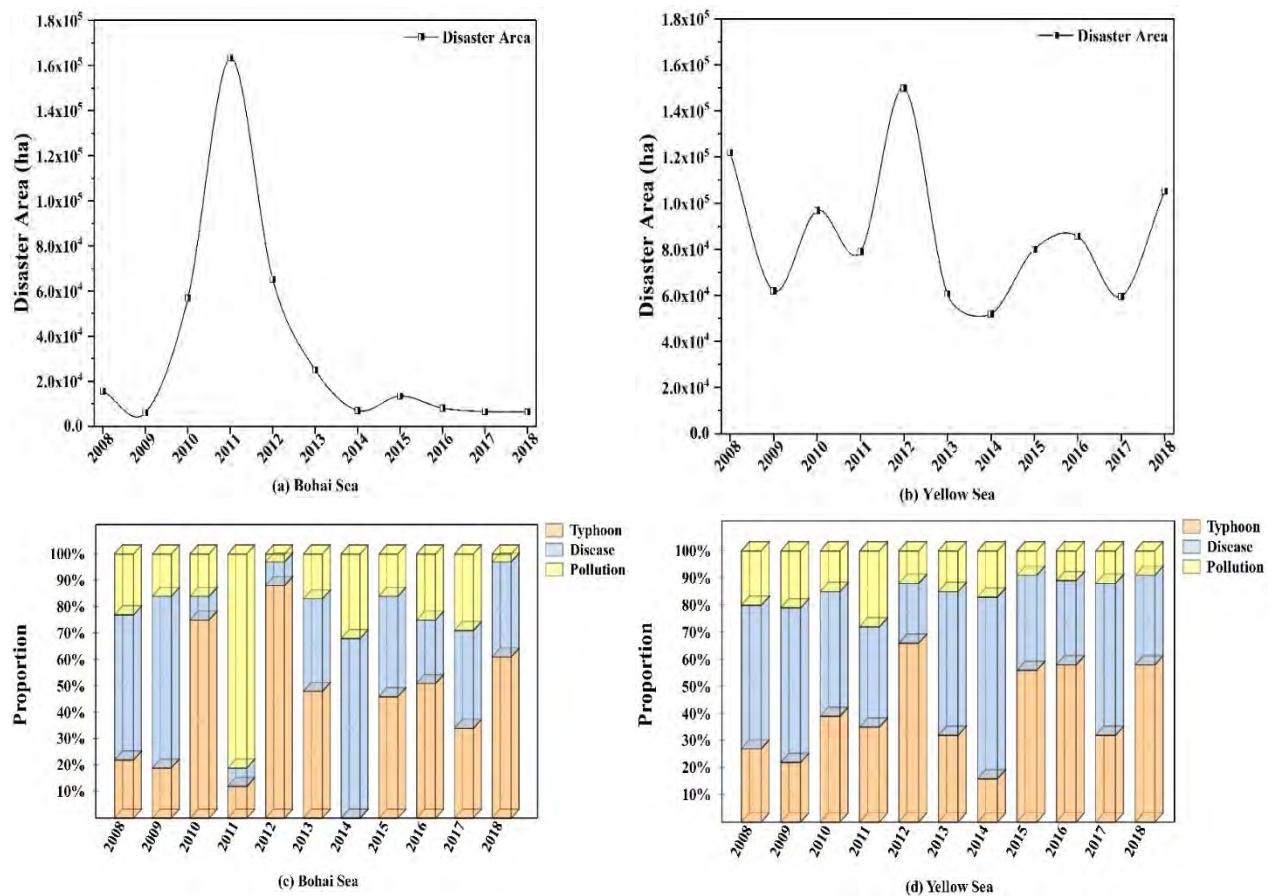
<sup>177</sup> Associated Press 2021

<sup>178</sup> Yu 2003

<sup>179</sup> Son et al. 2018



of typhoons, pollution and diseases in the Yellow Sea over a ten-year period showed that diseases were responsible in 35.1% of disaster areas in the Bohai Sea and 44.6% of disaster areas in the Yellow Sea (Figure 20).<sup>180</sup>



**Figure 20** Areas affected by typhoons, diseases, and pollution incidents in the (a) Bohai Sea, (b) Yellow Sea, and the proportion of each disaster category in the (c) Bohai Sea and (d) Yellow Sea in a given year from 2008 to 2018. (Zhang et al. 2022).

## 6 TRENDS IN KEY SPECIES

### Box 5 Species Trends

- Key stop-over and bottleneck of the world's most important flyway for migrating shorebirds, in terms of total numbers of birds (up to 50 million per year), diversity of species, and numbers (33 species) and proportion of threatened species using the flyway (Figure 21). Most key species are declining.
- Region-wide fisheries of great significance to three countries declining due to overfishing, with fishers shifting to catching less valuable species. The fisheries catch value peaked in 2000, at about 222.5 billion RMB (US\$ 30 billion).
- Few marine mammals and turtles remain but Spotted Seals are responding to recent conservation efforts and increasing.

<sup>180</sup> Zhang et al. 2022

Monitoring the population trends of key species of the ecosystem forms a systematic basis for underpinning an objective situation analysis. Taxa for which best data are available are birds and fish catches.

## 6.1 Birds

There is no formal mechanism for sharing information on birds or their conservation status within the Yellow Sea region, resulting in a number of information gaps. Global population estimates are available for the species that occur in the Yellow Sea<sup>181</sup> and estimates of the populations of migratory waterbirds in the EAAFP,<sup>182</sup> but these are based upon incomplete data. Although there are some estimates of known waterbird breeding colonies, there is no population data available for the majority of bird species within the Yellow Sea.

### *Breeding birds*

The importance of offshore islands (Taegam-do and Sogam-do) in the DPRK part of the Yellow Sea for breeding seabirds and breeding Black-faced Spoonbill and Chinese Egret was recognized several decades ago through the establishment of five Seabird Reserves.

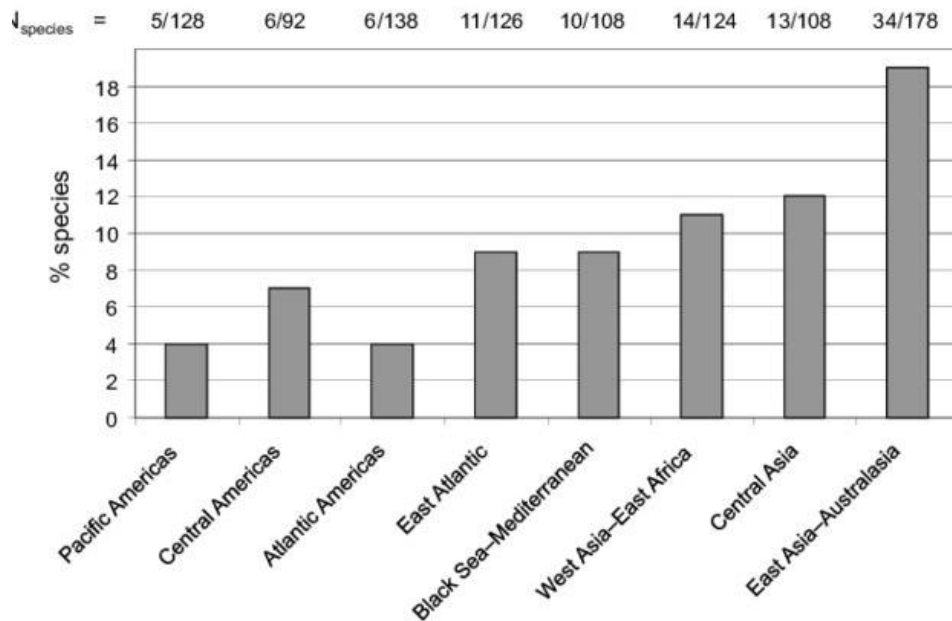
In the ROK, modern research on seabird colonies started in 1970, and the first seabird breeding colony in the ROK was designated as a National Natural Monument in 1982. Despite these advances, many potential breeding islands have never been surveyed, and species of conservation concern, such as the Chinese Egret and Styan's/ Pleske's Grasshopper Warbler (*Helopsaltes pleskei*), which mostly breed on Yellow Sea islands, lack recent field-based population estimates, either within the Yellow Sea or along the EAAF as a whole.

Some breeding birds of the Yellow Sea coasts are in a precarious situation and poorly documented. For example, several species nest on rocky islets including the endangered Chinese Crested Tern and Black-faced Spoonbill. The latter is a bridge species as it feeds on tidal flats.

---

<sup>181</sup> [www.datazone.birdlife.org](http://www.datazone.birdlife.org)

<sup>182</sup> Mundkur & Langendoen 2022



**Figure 21 Proportion of globally Threatened and Near Threatened waterbird species by flyway (MacKinnon et al 2012)**

*Non-breeding birds*

Tidal flats and their immediate hinterland are currently the best researched of the major habitats within the Yellow Sea region. Systematic bird surveys of the Yellow Sea coasts started in earnest in the 1990s and early 2000s,<sup>183</sup> have continued to increase in coverage and intensity in both PRC<sup>184</sup> and ROK in subsequent years, more recently extending to major sites of DPRK.<sup>185</sup>

Such data from the migratory bottleneck of the Yellow Sea can be augmented with count data from breeding sites at the northern end of the EAAF and non-breeding populations in the south, as well as by mark and resighting<sup>186</sup> and compiled and analysed by EAAFP Working Groups and Task Forces (including for Far Eastern Curlew, Spoon-billed Sandpiper, and Black-faced Spoonbill).

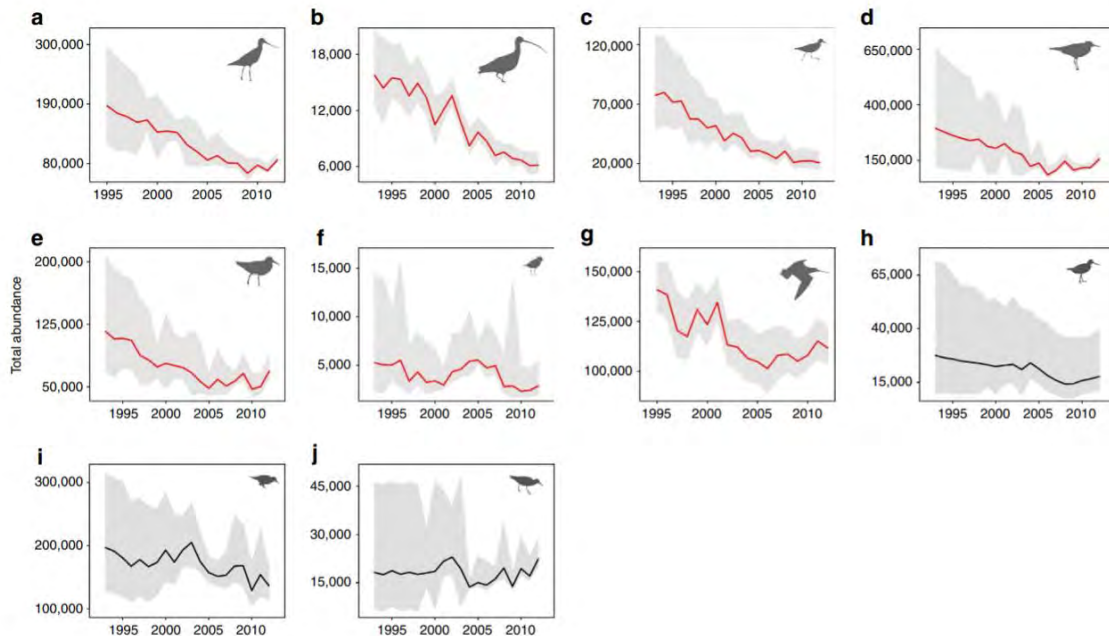
Wetlands International has recently completed a population review for the EAAFP of all migratory waterbird species, but data are still fragmentary and in many cases decades old.<sup>187</sup>

Rapid declines in many tidal flat dependent species were emphasized in the 2012 Situation Analysis.<sup>188</sup> Despite the efforts of all three countries to strengthen protection for habitats in the Yellow Sea, most especially in the intertidal zone, the trends for most species continue to decline.<sup>189</sup>

---

<sup>183</sup> Moores et al. 2001; Barter 2002  
<sup>184</sup> Bai et al. 2015; Choi et al. 2020a  
<sup>185</sup> Riegen et al. 2016a; 2016b; 2018a; 2018b; 2020  
<sup>186</sup> Green et al. 2021  
<sup>187</sup> Mundkur & Langendoen 2022  
<sup>188</sup> MacKinnon et al 2012  
<sup>189</sup> Piersma et al. 2016

Shorebird taxa with the greatest dependence on the Yellow Sea tidal flats are declining at a faster rate than those taxa which are less dependent (Figure 22).<sup>190</sup> Of a minimum of 27 globally threatened and near threatened waterbird species known to depend on the intertidal wetlands that occur regularly in internationally important concentrations in the Yellow Sea, 22 are now considered to be in decline.<sup>191</sup>



**Figure 22 Taxa are ordered from highest to lowest Yellow Sea reliance, the proportion of the flyway population that stages on Yellow Sea tidal mudflats to refuel for long-distance migrations. (Studds et al. 2017)**

(a) *menzbieri* Bar-tailed Godwit; (b) Far Eastern Curlew; (c) Curlew Sandpiper; (d) Great It; (e) Red Knot; (f) Lesser Sand Plover; (g) *baueri* Bar-tailed Godwit; (h) Terek Sandpiper; (i) Red-necked Stint; and (j) Grey-tailed Tattler. Total abundance estimates are posterior means from Bayesian N-mixture models of counts across Australia and New Zealand, including the majority of internationally important sites. Lines show posterior mean abundance estimates for each year, with red lines indicating taxa with credibly declining populations and grey shading denoting the 95% credible interval.

Appendix 1 displays a table of declining and threatened species of concern.

The rates of decline for many shorebird species are not equal to the rate of loss of coastal habitats. This suggests that there are a wide variety of factors, in addition to habitat loss, that are causing the observed shorebird population collapses.

## 6.2 Fish

A total of 276 species of fish have been recorded in the Yellow Sea.<sup>192</sup> Of the 100 commercial fisheries species in the Yellow Sea: 66% are demersal (bottom dwelling) fish, 18% are pelagic

<sup>190</sup> Studds et al. 2017

<sup>191</sup> Studds et al. 2017

<sup>192</sup> WWF 2006a

fish (swimming in the water column), 7% are cephalopods (octopus and squid), and 7% are crustacea (shrimps), of which 45% are warm-water species, 46% are warm-temperate species, and 9% are cold temperate species. In the Bohai Sea, 109 species of fish have been recorded. The principal source of information on Yellow Sea fish communities is from fisheries catch data. Widespread declines in abundance and diversity have been recorded, with several species now considered commercially extinct. Section 5.2 goes into further details on the fisheries of the Yellow Sea.

### 6.3 Marine mammals

Historically, large whales including Fin (*Balaenoptera physalus*) and Grey (*Eschrichtius robustus*) whales were abundant while summering and/or wintering in the Yellow and Bohai Seas. However, Japanese industrial whaling<sup>193</sup> and illegal mass operations by the Soviet Union with support from Japan<sup>194</sup> have caused major population declines of whales in the Yellow Sea. Recently, only 14 species of cetaceans (including Minke (*Balaenoptera acutirostrata*), Killer (*Orcinus orca*) and False Killer (*Pseudorca crassidens*) whales, and Finless Porpoises) and four species of seals have occurred regularly in Yellow Sea waters, , but these remnant populations tend to be in very small numbers.<sup>195</sup>

Spotted Seals are the only marine mammal species that is thriving and the only one resident in the Yellow Sea. This Yellow Sea population breeds in Liaodong Bay, with some migrating to waters of Incheon Ongjin County in the inner border region of Korea, and south to Garolim Bay in the ROK. DPRK's Haeju, Chodo, and Cheongcheongang estuaries are also known habitats of the Spotted Seal. The Yellow Sea population declined from an estimated 8,000 in the 1940s to an estimated 890 in 2007, largely as a result of historical hunting, with some still occasionally trapped accidentally in nets. It is now a major focus of marine mammal conservation activity within the Yellow Sea.

In 1992, PRC designated a National Nature Reserve for Spotted Seal in Dalian, and conservation efforts there and elsewhere in the Yellow Sea have resulted in an increase in numbers, with 2,000 individuals counted in 2015. Authorities in PRC have recently released several rescued and artificially bred seals into the Yellow Sea carrying satellite trackers.

In ROK the main sanctuaries for these seals are at Baengnyeong-do Island and Garolim Bay Marine Protected Area (designated in 2016). There have been tremendous efforts by the authorities and NGOs to persuade local residents to solve wildlife conflicts, such as the preparation of a win-win plan for local residents through the distribution of juvenile shellfish. Authorities have recently constructed artificial resting areas for use by the >300 seals that have overcrowded Mulbeom Rock (Figure 23).

The capture, killing and selling of protected marine mammals is strictly prohibited in PRC, however, incidental bycatch does occur due to extensive fisheries in coastal waters and the Yangtze River, resulting in increased mortality of both seals and Finless Porpoises. Pollution also leads to reproductive failure and decreased immune systems of marine mammals.

---

<sup>193</sup> Weller et al. 2002

<sup>194</sup> Berzin et al. 2008

<sup>195</sup> WWF 2006b

The semi-marine Eurasian Otter (*Lutra lutra*) also occurs sparsely in river estuaries of the Yellow Sea. Fragmentation of populations by coastal development affects these otters in ROK, making it very rare in PRC.



**Figure 23 Artificial seal resting platforms in ROK © Park Jeong Woon 2019**

#### **6.4 Invertebrates**

The majority of invertebrates in the Yellow Sea, including several important commercial species of squid, shellfish and crustaceans continue to show sharp declines, with the exception of a few species of *Potamocorbula*, a small clam which seems to thrive in polluted habitat.<sup>196</sup>

*Potamocorbula laevis* has shown a massive decline at Yalujiang near Dondang port, PRC<sup>197</sup> but is still present at Nanpu near Tianjin, where overfishing of predatory shrimps is thought to have resulted in dense populations.<sup>198</sup> Overall, although the relative proportions of invertebrates have increased, the biomass densities in the Bohai Sea have displayed an overall downward trend from 1982 to 2015.<sup>199</sup> In many areas, there has been a shift to commercial species now dominating as a result of people introducing seed stocks in new areas.<sup>200</sup> The straightening and damming of rivers is also affecting estuarine benthic diversity and abundance.

Several endemic invertebrates, such as subspecies of amphioxus (*Branchiostoma belcheri*), have recently been categorised as threatened.<sup>201</sup> Similarly, the Chinese Shrimp (*Fenneropenaeus chinensis*), an economically important species that inhabits the northern Yellow Sea and was formerly relatively abundant (in 1979 production was 40,000 tons), was listed as Endangered in 2005 due to overfishing.<sup>202</sup>

Research conducted in the northern Yellow Sea has shown that 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 have become the dominant species.<sup>203</sup>

---

<sup>196</sup> Murray et al. 2015

<sup>197</sup> Zhang et al. 2018

<sup>198</sup> Yang et al. 2016

<sup>199</sup> Wu et al. 2019

<sup>200</sup> Peng et al. 2021

<sup>201</sup> UNDP/GEF 2007

<sup>202</sup> Liu 2013

<sup>203</sup> Zou et al 2013

## Case Study 2 Yalu River Estuary National Nature Reserve

The Yalu River Estuary Nature Reserve (hereafter Yalujiang) was established in 1987 and upgraded to a National Nature Reserve in 1997 with an area of 108,057 ha. It is located on the west side of the mouth of the Yalu River (Amnok River), which acts as the border between the PRC and DPRK. It extends along the coast for 70 km, and encompasses more than 25,000 ha of tidal flats, with a width of 2-6 km.

The importance of the site for waterbirds was discovered in 1999,<sup>204</sup> after which the Pūkoro Mirando Naturalists' Trust (based in New Zealand) began a series of surveys during northward migration;<sup>205</sup> now succeeded by the PRC Coastal Waterbird Census.<sup>206,207</sup> Ecological studies on shorebird foraging ecology and benthos started in 2010 and continue to the present day, providing one of the most detailed long-term datasets anywhere within the Yellow Sea.

Yalujiang supports some 250,000 shorebirds on northward migration, and is of international importance for 17 shorebird species.<sup>208</sup> Following the destruction of Saemangeum, ROK in 2006 it is the most important site in the EAAF for the Bar-tailed Godwit and the Great Knot.<sup>209</sup>

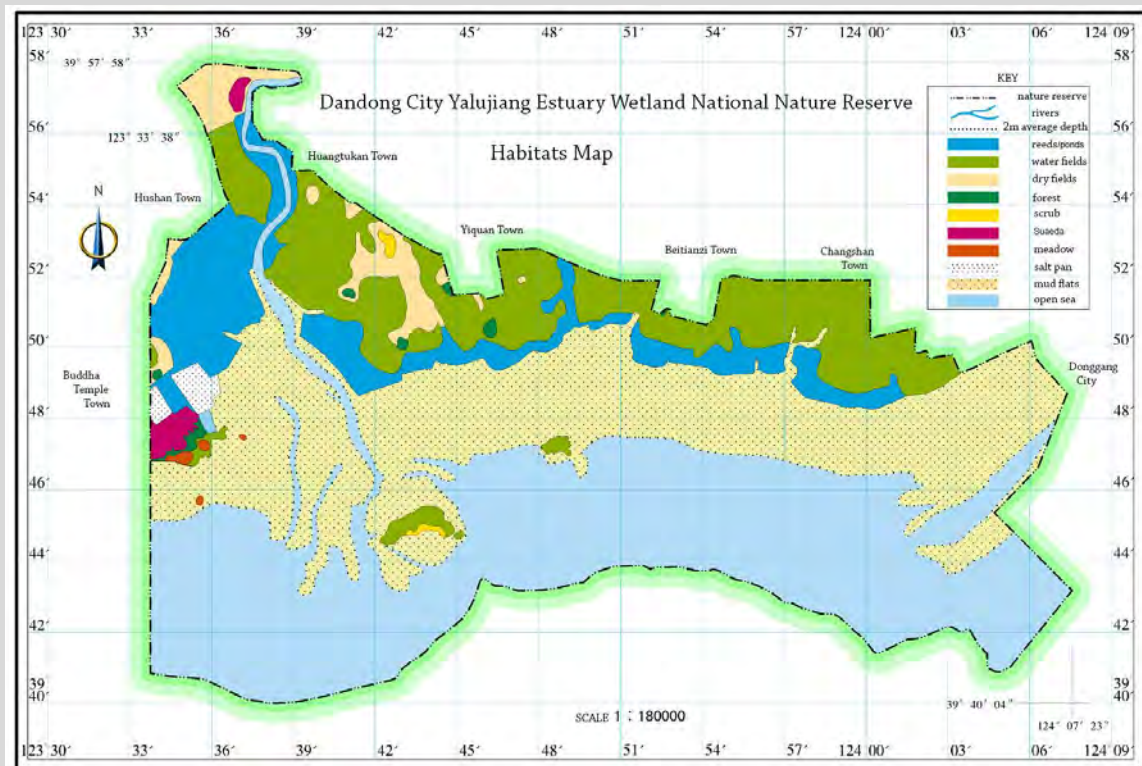


Figure 24 Vegetation types of Yalujiang NNR. © WH Nomination Dossier Phase 2

<sup>204</sup> Barter et al. 2000

<sup>205</sup> Riegen et al. 2014

<sup>206</sup> Bai et al. 2015

<sup>207</sup> Choi et al. 2020a

<sup>208</sup> Bai et al. 2015

<sup>209</sup> Choi et al. 2015

The main food item for both the Bar-tailed Godwit and Great Knot in 2011/2012<sup>210</sup> was the small clam *Potamocorbula laevis*, which occurred in densities >1000/m<sup>2</sup>.<sup>211</sup> The population of *P. laevis* declined dramatically between 2011 and 2014, leading Great Knots to shift to other species, in particular, the snail *Umboonium thomasi*.<sup>212</sup> Due to the very hard shells, Great Knots had to increase the size of the gizzard to crush them and the rate of food intake was reduced due to the need to regurgitate shell fragments, rather than pass them with the faeces.<sup>213</sup>

There has been a significant reduction in numbers of both Bar-tailed Godwits (-60%) and Great Knots (-25%) following the disappearance of *P. laevis*.

There also have been changes in the migration strategies of Bar-tailed Godwits. Birds of the *baueri* population (breeds Alaska; winters PRC to New Zealand) are now leaving New Zealand earlier and spending longer staging in the Yellow Sea, which is likely associated with a need to spend longer refuelling before their onward flight to the breeding grounds in Alaska.<sup>214</sup> Furthermore, the number of birds of the *menzbieri* population (breeds Siberia; winters SE Asia to Australia), that used to arrive at Yalujiang several weeks later than *baueri* have declined by 95%,<sup>215</sup> suggesting that *baueri* have consumed much of the available prey, leaving little for later arrivals.

The disappearance of *P. laevis* coincided with the rapid development phase of Dandong Port, which began in 2010 and included dredging of the shipping channel from -8 m to -16 m and the construction of a 10km long port peninsula at the mouth of the Yalu (Amnok) River. (Dandong Port was the only Public-Private Partnership (PPP) port in PRC; however, changing economic conditions contributed to its demise. It was declared bankrupt in 2017 and subsequently has been taken over by a state-owned entity.)

Port development extended 10 km out to sea by 2015, deflecting the discharge of freshwater offshore. It is thought that resulting changes in salinity may have led to the disappearance of the clam *Potamocorbula laevis* from the Yalujiang Nature Reserve.

Land use rights for the intertidal areas of the nature reserve, including the 'core' area, are held by local communities, and there is extensive mollusc aquaculture of species such as the Chinese Razor Clam (*Sinonovacula constricta*) and Surf Clam (*Macra veneriformis*). Shortage of prey has increased competition between shorebirds and fishers, with birds consuming large quantities of young *M. veneriformis* that were seeded on to the flats, resulting in significant financial loss.

The situation at Yalujiang is typical of many parts of the Yellow Sea, and there is an urgent need to better understand interrelationships between natural and managed shellfish stocks and shorebird foraging to inform future sustainable management decisions. The fact that fishers and conservationists share a common vision for healthy tidal flats is a strong starting point for consensus building for a sustainable future.

Surveys in March/April 2018 revealed that mollusc food stocks for Great Knots were very low, possibly associated with severe cold weather during the previous winter.

---

<sup>210</sup> Choi et al. 2017

<sup>211</sup> Choi et al. 2014

<sup>212</sup> Zhang et al. 2019b

<sup>213</sup> Zhang et al. 2019c

<sup>214</sup> Conklin et al. 2021

<sup>215</sup> Zhang et al. 2018



A community group, the 'Dandong Happy Dedicated Volunteers,' spearheaded a programme to provide supplementary food for the birds so that they could put on adequate fat stores to enable migration to their Arctic breeding grounds. Over 100 tonnes of *P. laevis* were sourced from a site in Bohai where they were harvested sub-tidally so as not to impact shorebird feeding elsewhere. The clams were distributed over the tidal flats from a fishing boat over spring tides (Figure 25) and the birds found them very quickly once the tide had fallen – over 13,000 Great Knots were recorded in one 4 ha plot. Such interventions may become increasingly necessary if food stocks continue to decline.<sup>216</sup>



**Figure 25 (a) *Potamocorbula laevis* (b) Distributing *P. laevis* from a fishing boat at high tide (Source: Shoudong Zhang).**

#### **Lessons from Yalujiang**

Coastal development projects can have impacts reaching far beyond the immediate footprint of land claim, affecting coastal sediments and water flows, and resulting in impacts to food supplies for waterbirds.

When facing a massive reduction in available food stocks, birds may try to move to alternative sites, but there has been such extensive habitat loss around the Yellow Sea that this may no longer be possible. In the absence of alternative sites, birds may try to adapt to different prey. If this is not possible, they will die. Survival rates of both *baueri* and *menzbieri* Bar-tailed godwits are declining<sup>217,218,219</sup> indicating increased mortality.

The situation at Yallujiang is similar to the impacts resulting from the Saemangeum Reclamation project in ROK, which directly destroyed a major intertidal area, resulting in population declines of many shorebirds, in particular the Great Knot.<sup>220</sup> Great Knots, like Red Knots, are highly specialised molluscivores, making adjustment to alternative prey more difficult than for more generalist feeders.

This case demonstrates that it is possible to organize artificial provisioning on a massive scale to meet the immediate needs of a passage migratory bird population. In this case, the food source was harvested from the wild at another location, however it may be possible to rear these in farms. This may become a vital future management technique to maintain some species.

---

<sup>216</sup> Zhang et al. 2021

<sup>217</sup> Piersma et al. 2016

<sup>218</sup> Conklin et al. 2016

<sup>219</sup> Murray et al. 2017

<sup>220</sup> Moores et al. 2016

## 6.5 Other species of interest

Five species of sea turtles are found around the coasts of Korea and Jeju Island and occasionally enter the Yellow Sea, with the majority of records attributed to Loggerhead (*Caretta caretta*) and Green turtles (*Chelonia mydas*). Olive Ridley (*Lepidochelys olivacea*), Hawksbill (*Eretmochelys imbricate*) and Leatherback sea turtles (*Dermochelys coriacea*) are much more rare.<sup>221</sup> Studies of recovered turtles indicated that the main food items found in loggerheads were jellyfish (*Cyanea nozakii*) and the swimming crab (*Portunus trituberculatus*). In Green Turtles, the most common food item was kelp.

Terrestrial mammals of concern in the reedbeds and marshes of Jiangsu include a thriving population of re-introduced Père David's Deer (*Elaphurus davidianus*) and the endemic Chinese Water Deer (*Hydropotes inermis*).

## 7 RECENT IMPROVEMENTS IN THE PROTECTION, CONSERVATION MANAGEMENT AND RESTORATION OF THE INTERTIDAL ECOSYSTEMS OF THE YELLOW SEA

### Box 6 Policy and Governance Changes Since 2012

There have been many improvements to governance and policy in all three countries:

- There are moratoria on coastal land claims in PRC and ROK, but several claims continue to go ahead. This is especially true in DPRK where no moratorium has been put in place.
- In 2014, DPRK revised its Environmental Impact Assessment (EIA) law to stipulate the evaluation of all marine and coastal developments to prevent damage to environment.
- PRC has begun applying ecological red lines, including marine ecological red lines.
- In 2017, the PRC Ministry of Agriculture issued the "Planning of the Tidal Flats in Aquaculture Waters."
- Coastal protected areas increased significantly in ROK and DPRK (more than 250,000 ha) but was reduced by approximately 100,000 ha in PRC due to boundary revisions.
- Phase I serial World Heritage properties were inscribed by UNESCO's World Heritage Committee for PRC (188,643 ha plus a buffer zone of 80,056 ha) and ROK (128,411 ha and their buffer zone is 74,592 ha), Phase II nominations are in progress.
- In DPRK, research, monitoring and identification of priority sites has advanced and a new dedicated academy has been established.
- There has been a large increase in awareness and public support for conservation in all three countries.
- Important regional conservation projects have been undertaken (Yellow Sea Large Marine Ecosystem (YSLME), ADB, EAAFP).

---

<sup>221</sup> Kim et al. 2021b

- A number of coordination agencies have been established or strengthened (IUCN led Yellow Sea Working Group, EAAFP Yellow Sea Ecoregion Task Force).

## 7.1 Coastal governance and policy

### 7.1.1 International policy and governance

Following the publication of the 2012 IUCN *Situation Analysis*<sup>222</sup>, at the IUCN World Conservation Congresses in 2012 and 2016 IUCN Resolutions 5.028 and 6.026<sup>223</sup> were adopted, emphasizing the importance of the Yellow Sea region intertidal zone and the urgent need for its protection.

These resolutions led to the development of the Yellow Sea Working Group. At a side meeting of the Symposium held in Yancheng, Jiangsu Province, PRC in December 2017, considering the transboundary nature of the Yellow Sea ecoregion, participants from the three countries agreed to have the joint Working Group on the Conservation of the Yellow/West Sea Intertidal and Associated Coastal Wetlands. It is facilitated under the umbrella of IUCN, EAAFP and Ramsar Regional Center - East Asia (RRC-EA), with the support of Hanns Seidel Foundation Korea Office. Its main objective is to facilitate common approaches to the protection, management and restoration, of intertidal wetlands between PRC, DPRK and ROK.

Since the first meeting in 2017, Yancheng has hosted almost annually a series of high-profile international symposia on coastal wetlands, with a focus on the Yellow and Bohai Seas. The outcomes of these meetings included the 2017 Yancheng Declaration (Y17), the 2018 End of Symposium Statement (Y18), the 2019 Yancheng Consensus (Y19) and the 2020 Statement of Outcome (Y20) (Appendix 8), all of which included recommendations reflected in section 8 of this report.

PRC's Ministry of Natural Resources is enabling the establishment of a World Coastal Forum, with its first conference to be hosted by Yancheng in the latter part of 2023. This is a direct consequence of the 2012 and 2016 IUCN resolutions and a subsequent 2020 IUCN resolution, and follows a 2017 Resolution of the Convention on Migratory Species (CMS)<sup>224</sup>, 2018 Ramsar Resolution<sup>225</sup> and 2018 decision of the Convention on Biological Diversity (CBD)<sup>226</sup>. The World Coastal Forum is intended to facilitate implementation of the various commitments made to coastal biodiversity conservation.

Through these initiatives, cooperation between ROK, PRC and DPRK is being strengthened for migratory waterbirds and habitat conservation.

---

<sup>222</sup> Mackinnon et al 2012

<sup>223</sup> IUCN 2016

<sup>224</sup> Convention on Migratory Species Resolution 12.25 Promoting Conservation of Critical Intertidal and other coastal Habitats for Migratory Species

<sup>225</sup> Ramsar Convention Resolution XIII.20 Promoting the conservation and wise use of intertidal wetlands and ecologically-associated habitats

<sup>226</sup> Convention on Biology Diversity Decision 14/30 Cooperation with other conventions, international organizations and initiatives

The UNDP Transboundary Diagnostic Analysis for the Yellow Sea Large Marine Ecosystem<sup>227</sup> has been finalised and endorsed by PRC and ROK. It is important that this stands as more than a finished exercise but leads to follow-up change and implementation of recommendations contained. The report focusses on seven main issues: 1. fishing effort exceeding ecosystem carrying capacity; 2. unsustainable mariculture; 3. pollution and contaminants; 4. eutrophication; 5. change in ecosystem structure; 6. habitat loss and biodegradation; 7. climate change; and recommends actions aimed at addressing the root causes of these problems.

### 7.1.2 National Governance and policy

#### **Democratic People's Republic of Korea**

- DPRK has ratified the Ramsar Convention and designated two Ramsar sites including one site, Mundok Migratory Bird Reserve, on the Yellow Sea.
- DPRK EIA law was revised in 2014 to include: Institutions in charge of exploiting natural resources, and institutions, enterprises, and organizations concerned that wish to develop marine resources or undertake construction projects along seashores, shall have them evaluated for their impact on the marine environment and take measures to prevent marine pollution.

#### **People's Republic of China**

- PRC has made important advances through a major reorganization of ministries and their responsibilities to limit fragmentation of coastal governance. The Ministry of Natural Resources (MNR), established in 2018, is responsible for the management of biodiversity from the mountain top to ocean. This has streamlined the efficiency of planning, managing and reporting on wetland protected areas. Where there were formerly several different agencies responsible for different protected areas and international programmes, now all functions are brought together under the single agency the National Administration of Forests and Grasslands, under the MNR. However, responsibility for representation in the CBD and UNFCCC lies with the Ministry of Ecology and Environment and there is scope for improvement in synergies between the two ministries.
- In PRC, policy influencing the Yellow Sea has been transformed after the adoption of a new national guiding principle, the development of an 'ecological civilization.' This is backed up by a number of legal and regulatory changes:
  - A revision of the Wildlife Protection Law, adding many species to the protected schedules and including habitats for the first time;
  - Tightening environmental laws and regulations relating to pollution, including closure of many polluting and illegal factories, and banning the use of some chemicals;
  - Adoption of new performance indicators for projects and civil servants to include the ecological consequences of their actions;
  - Restrictions on corruption, including withdrawal of some local government decision making powers to ensure more central oversight;

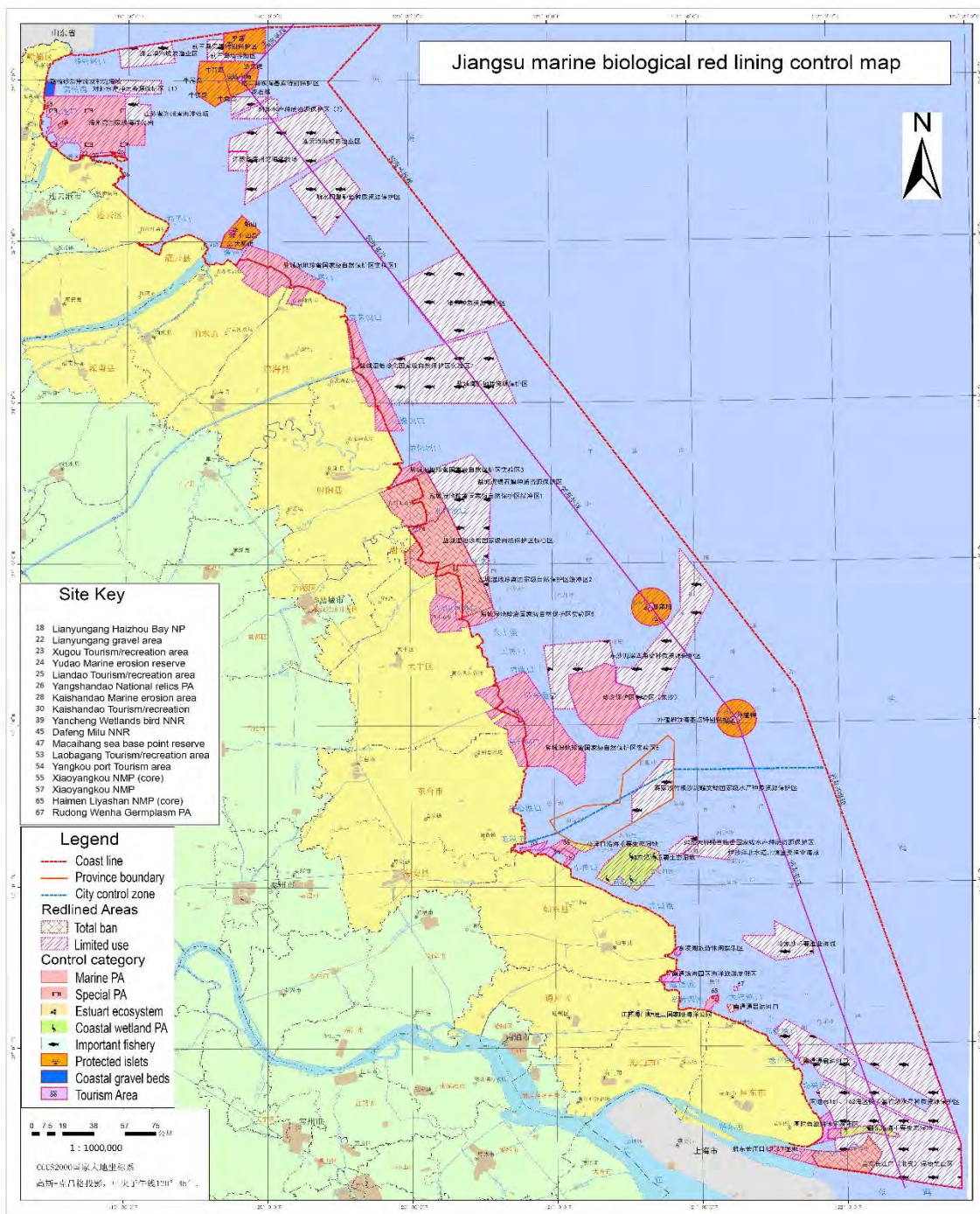
---

<sup>227</sup> UNDP 2020

- Issuing new regulations banning further coastal land claims and encouraging restoration of many unregistered fish farms to natural wetlands;
  - New regulations from the National Administration for Forests and Grasslands in 2019, banning the construction of wind farms in sensitive migratory bird flyways, so wind farm development has been reduced, but offshore wind farm development continues;
  - Release of the “Outline Plan for ecological protection and high-quality development of the Yellow River basin”, with Chapter 8 outlining plans for strengthening the control of the environmental pollution system, tackling farmland pollution, industrial pollution and urban pollution and Chapter 5 promoting downstream wetland protection and ecological governance, including actions in the delta and coastal areas;
  - Creation of new PA category – National Park – to form the heart of the national PA system.
- Following the 18<sup>th</sup> Party Congress of the Chinese Communist Party, the country has embarked on a programme of ecological red lining to control the spatial planning of developments that would damage ecological functionality. Areas of importance for the delivery of ecological services including biodiversity conservation and areas of ecological fragility are demarcated as falling within the ecological red line, which restricts the level of development and other activities. All nature reserves, national nature reserves, and national parks are included within the red line, but it also applies to many other levels of protection, including resource reserves and fishing control areas.
  - In 2012, the State Oceanic Administration launched the delineation of red lining in the Bohai Sea, aiming to implement a stricter marine ecological protection system. Such red lined areas refer to strictly protected marine ecological space for sensitive and fragile ecological areas and areas of extremely important ecological function, such as biodiversity conservation and coastal ecological stability.<sup>228</sup> Currently such red lined areas cover about 30 percent of the total coastal management area of PRC. Figure 26 gives an example of the various additional layers of protection.

---

<sup>228</sup> Zhao et al. 2021



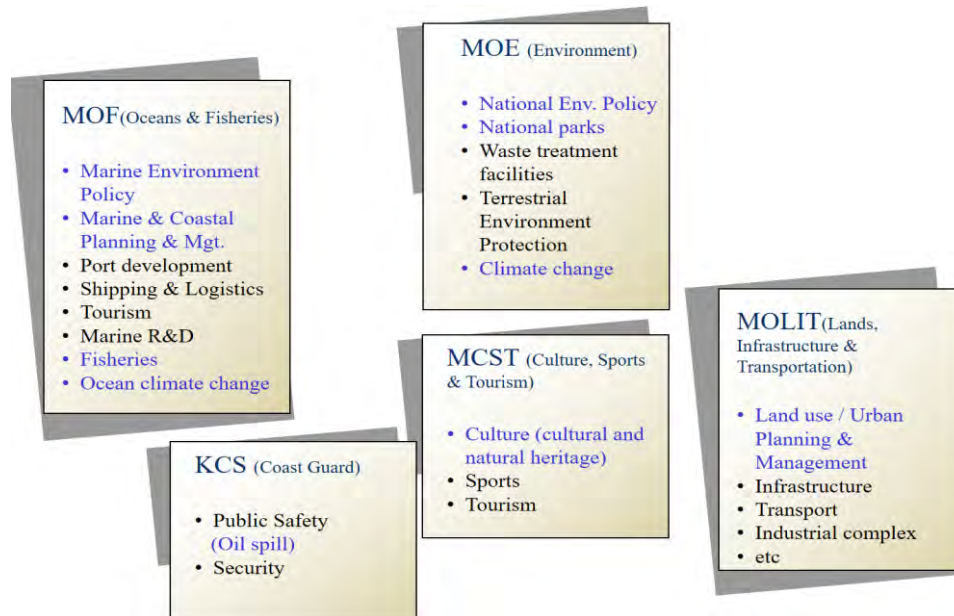
**Figure 26 Marine and coastal protected areas and zones of Jiangsu province, PRC. (Jiangsu Marine and Fisheries Bureau 2016).**

### Republic of Korea

- Responsibility for the coastal environment is divided among a variety of national ministries and agencies (Figure 27).

Enacted in 1999 and amended in 2016, ROK's Wetlands Conservation Act aims to contribute to the conservation of wetlands and wetland biodiversity and to promote

international cooperation in line with the Ramsar Convention. The Act strengthens many regulations relating to the establishment of Wetland Protected Areas.



**Figure 27 Marine Environment Protection Governance of ROK (modified from Nam 2017)**

- In March 2009, the "Tidal Flat Restoration Promotion Plan" was established in ROK. This led to the 2016 establishment of "Guidelines for the Restoration of the Tidal Flat Ecosystem (Ministry of Oceans and Fisheries Directive No. 357) and the 2018 "Mid-term Promotion Plan for the Restoration of the Tidal Flat Ecosystem (2019-2023)."
- ROK enacted the Public Waters Management and Reclamation Act in 2010, which protects marine and coastal waters and reclaimed lands from: dumping or discharging wastes, waste oil, wastewater, sewage, excreta, livestock excreta, polluted soil, poisonous substances, animal carcasses, or other pollutants prescribed by Ordinance of the Ministry of Oceans and Fisheries, on or into public waters; opening, closing or damaging any floodgate or installations for managing public waters; and abandoning or leaving a ship derelict on public waters. New construction, excavation and dredging, can only be undertaken with special permits.
- ROK's Environmental Impact Assessment Act was wholly amended in 2012. This Act helps to prevent environmental destruction and pollution, and to promote Environmentally Sound and Sustainable Development (ESSD), thus establishing and maintaining a healthy environment, and offering increased opportunity for public opinion and inspection of plans.
- The Act on the Sustainable Management and Restoration of Tidal Flats (Getbol) and Adjacent Areas Thereof (the Getbol Act) was enacted in January 2019 and came into force in January 2020, covering the comprehensive management, including protection and restoration, of tidal flats. Under the Getbol Act, The Master Plan on Management and Ecological Restoration of Tidal Flat and Adjacent Areas, first edition (2021-2025) was released in September 2021.
  - The Plan includes three major goals: 1) Strengthen the scientific basis and integrated management of tidal flat threats; 2) Discover various values and enhance utility; 3) Systemize the entire cycle of tidal flat restoration.

- The 5 main strategies to achieve the goals in the plan are: 1&2) Strengthen and expand tidal flat management; 3) Restore carbon sinks through tidal flat recovery; 4) Increase tidal flat ecosystem service provision; 5) Secure the governance of tidal flat management.
- The Master Plan will govern the tidal flat status surveys, enhance the management system for tidal flat restoration and various restoration projects, and provide customized conservation and management for each of the tidal flats.
- MOF plans to carry out tidal flat restoration in 25 locations, covering 300 ha of tidal flats, including closed salt pans and closed aqua farms, by the year 2023. The restoration projects will not be a one-size-fits-all type; each location will be reviewed and the most effective methods will be adopted for each restoration site. Restoration of the tidal flats is aimed at supporting active and healthy ecological processes. These restored habitats will restore feeding and resting areas for the migratory waterbirds.
- The implementation of the Plan will progress the implementation of the tidal flat conservation policy of the ROK Government.
- Following the 2021 Phase I Getbol, Korean Tidal Flats World Heritage inscription, wetland habitats' "outstanding universal value" is better recognized. Not only does it provide habitats for migratory waterbirds, but it plays a key role in 'blue carbon' storage, and in supporting aquaculture to the benefit of local communities.
- As part of the national commitment to restore 15% of degraded ecosystems under the CBD, MOF plans to restore extensive tidal flats, expand tidal flats nomination as Ramsar Sites, and further strengthen international cooperation with advanced countries in tidal flat management such as the three countries along the Wadden Sea.

## 7.2 Protected area expansion

All three countries have added additional coastal wetland protected areas and marine protected areas, including the successful World Heritage inscription of the Yellow Sea Phase I serial nominations in PRC and ROK, with Phase II nominations underway, and consideration being given in DPRK to submit a nomination. Appendix 4 provides details of the most important sites.

### Protected area expansion in the Democratic People's Republic of Korea

- In DPRK, a total of 55 wetlands nationwide have recently been assessed as nationally or internationally important, and are listed in the revised National Wetlands Inventory and formally published.<sup>229</sup> Of these wetlands, 24 are on the Yellow Sea coast.
- DPRK has developed its first National Biodiversity Strategy and Action Plan (NBSAP) and submitted its 5<sup>th</sup> National Report on Biodiversity to the CBD.<sup>230</sup>
- As a follow-up to the NBSAP, DPRK has also implemented the UNDP/GEF project on "Coastal Biodiversity Management of DPR Korea's West Sea." The project has focussed on developing and implementing an integrated coastal zone management

---

<sup>229</sup> MoLEP 2018

<sup>230</sup> DPRK 2016

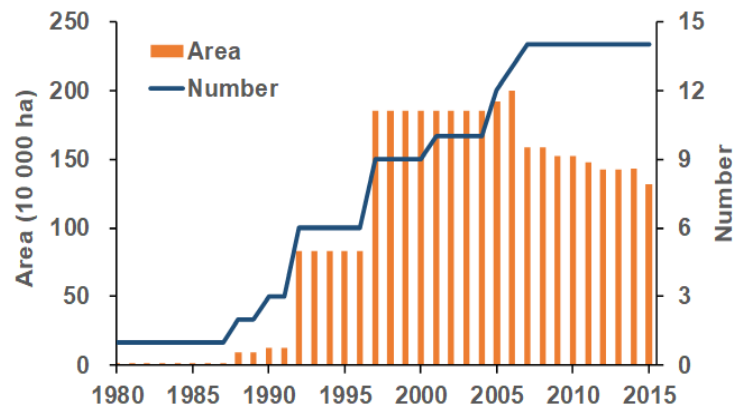


plan for South Pyongan Province and biodiversity management and protection efforts at the Mundok Reserve on the Chongchan Estuary.

- DPR Korea has established a number of Migratory Bird Reserves for several decades, but lacks the technical capacity or equipment to manage them or monitor the numbers and species making moulting stopovers or on passage. This has been improving over recent years with assistance from organisations including the Hanns Siedel Foundation, Pūkorokoro Miranda Naturalists' Trust and EAAFP. This growing international cooperation has been halted by the COVID pandemic, but will hopefully be restarted as soon it is as safe to do so.
- DPRK joined the Ramsar Convention and EAAFP in 2018 and declared two Ramsar sites, one of which – Mundok Migratory Bird Reserve – lies within the Yellow Sea Ecosystem and is also designated as an EAAFP Flyway Network Site. Mundok is important for 4 species of cranes, many waterbirds, Swan Goose (*Anser cygnoid*) (staging area for more than 50% of global population), and also as one of the principal migratory staging areas for Far eastern Curlew.
- DPRK currently has a total of five Migratory (wetland) Reserves, five Sea Bird Reserves and six Marine Protection Areas in the Yellow (West) Sea.

#### **Protected area expansion in the People's Republic of China**

- PRC has been expanding its protected area system for several decades. Recent additions have focused on wetlands and a policy has been adopted to include at least 50% of remaining natural wetlands in protected areas. Various analyses have pointed out that there are some important gaps in coastal coverage, especially in Jiangsu Province.
- There has been rapid growth in the number and area of Nature Reserves (NR) and National Nature Reserves (NNRs) in PRC over the last three decades (Figure 28). The total area of coastal NNRs reached its maximum of 2.01 million ha in 2006, including 199,000 ha of tidal wetlands, 1.17 million ha of open ocean, and 674,000 ha of land claimed area, when they were designated. The area then decreased as a result of boundary adjustments or losses for development and coastal land claim. As a result, the area in NNRs in 2015 was only 66.1% of that in 2006. A total of eight NNRs underwent boundary adjustments; three sites were adjusted twice.



**Figure 28 Change in number and area of national nature reserves (NNRs) along the Yellow Sea coast in PRC (Ma et al. 2018)**

### Protected area expansion in the Republic of Korea

- In 2021, the World Heritage Committee inscribed the Getbol, Korean Tidal flats as a natural World Heritage property on the Yellow Sea coast, with a Phase II nomination in preparation.
- ROK's Protected Areas include: 32 Marine Protected Areas (MPAs) totalling 179,869 ha; 14 Wetland Protect Areas totalling 143,780 ha; 15 Marine Ecosystem Protected Areas totalling 26,152 ha; 2 Marine Species Protected Areas totalling 9,414 ha and 1 Marine Scape Protected Area of 523 ha. However, as of 2021, marine protected areas in ROK reached just 2.12% of the total marine area, well below the target of 10%.
- Ministry of Environment and MOF are working to develop effective road maps to enlarge designated protected areas, identify new potential protected areas and improve management.
- As part of the national commitment to restore 15% of degraded ecosystems under the CBD, MOF plans to restore extensive tidal flats. MOF plans to expand tidal flat nominations for Ramsar Sites, and further strengthen international cooperation with countries with advanced tidal flat management expertise, such as the three countries along the Wadden Sea. Furthermore, the cooperation system among ROK, PRC, Russia and DPRK will be strengthened for migratory waterbirds and habitat conservation.
- Based on the Wetlands Conservation Act, the ROK government, in the process of preparing for the inscription in World Heritage List, expanded wetland protected areas from 10,762 ha to 129,346 ha in 2018. Marine protected areas were expanded from 18 locations with 36,031 ha in 2012 to 30 locations with 178,436 ha in 2020.
- As of December 2021, 7,963.58km<sup>2</sup> of coastal and marine areas has been designated as protected areas. This accounts for 2.12% of Korea's entire ocean area. Every year, the Korean government, in cooperation with local communities, designates one or two marine protected areas to improve the health of the marine ecosystem and preserve biodiversity.

### 7.2.1 Expansion of EAAFP Flyway Network Sites Network

The EAAFP network has expanded to several new Flyway Network sites in the Yellow Sea. The ROK has designated four new sites including: Incheon Songdo Tidal Flat, Hwaseong Wetlands, Daebudo Tidal Flat and Chilbaldo Islet, Gochang Getbol. PRC has designated a new site in Rongcheng Swan National Nature Reserve. DPRK has designated its first two sites, Mundok Wetland Reserve and Kumya Wetland Reserve.

### 7.2.2 Progress in relation to the World Heritage Convention

The establishment of serial World Heritage properties can be an effective way to provide protection at the international level to key migratory bird sites around the Yellow Sea and ensure the highest level of national attention. This can only be achieved only if integrity, protection and management requirements are met.

The World Heritage Committee has inscribed two natural World Heritage properties along the Yellow Sea on the World Heritage List; one in PRC, Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I), and one in ROK, the Getbol, Korean Tidal Flats. In both cases the IUCN evaluation<sup>231</sup> considered that there remained conservation issues to be addressed with the nominated properties, which should have been addressed prior to inscription. The eventual decisions taken by the World Heritage Committee defined a series of conservation actions that are expected to be undertaken by PRC and ROK.<sup>232</sup>

The Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I), PRC's serial WH property in the Yellow Sea, comprises two large sections of the Jianguo coastline, mostly in Yancheng NNR. The nomination was accepted by the World Heritage Committee in 2019 based on the understanding that a single Phase II nomination would be prepared by PRC "to reflect the full range of natural wealth and diversity of the ecoregion and to meet integrity requirements".<sup>233</sup>

In 2021 PRC has submitted a nomination of additional Yellow Sea and Gulf of Bohai component parts as a proposed Phase II extension to the Phase I property. This nomination is currently under evaluation and due to COVID-19 the evaluation mission has been postponed, but is expected to proceed in 2023 and to be tabled at the World Heritage Committee's session in 2024. Given the ongoing evaluation by IUCN, the present situation analysis is not able to make any direct comment on the nomination, since IUCN will provide its recommendations in the context of the evaluation of the nomination.

ROK is well advanced in preparation of its own Phase II nomination but the list of proposed component parts remains unofficial at the present time.

DPRK only has two cultural properties inscribed on the UNESCO World Heritage List and five sites on their Tentative List. DPRK has not yet nominated any migratory bird sites for WH status, but they have nominated Mt Kumgang as a mixed site in 2021, and this site is also currently within the IUCN evaluation process, with delays due to the presence of COVID-19

---

<sup>231</sup> IUCN 2019 and 2021

<sup>232</sup> World Heritage Committee 2019 and 2021

<sup>233</sup> <https://whc.unesco.org/en/decisions/7358>

restrictions. The State Party has also requested International Assistance under the World Heritage Convention to update the State Party's Tentative List.

### Case Study 3 Serial World Heritage property in PRC

Yancheng, Jiangsu Province, PRC is used by the widest range of endangered migratory shorebirds of the EAAF and is regarded as indispensable to some of them such as the Spoon-billed Sandpiper, Far Eastern Curlew, Nordmann's Greenshank (*Tringa guttifer*) and Saunders's Gull (*Saundersilarus saundersi*). It also offers the widest range of habitats and supports important wintering and summer breeding species in addition to the spring and autumn passage migrants. It is the world's most important breeding area for the Vulnerable Saunders's Gull most important wintering area for the western population of the much admired and Endangered Red-crowned Crane (*Grus japonicus*) and is also important for wintering Oriental White Storks (*Ciconia boyciana*).

Informed by IUCN's 2012 *Situation Analysis*<sup>234</sup> and subsequent IUCN resolutions,<sup>235</sup> a dossier for the first part of a serial nomination was completed and submitted to UNESCO in January 2018. The serial property inscribed by UNESCO's World Heritage Committee at its 2019 meeting in Baku, Azerbaijan included adjacent habitat in Tiaozini and Dongsha. The Committee based its inscription decision on the understanding that the State Party would submit a single Phase II nomination for consideration by the Committee in 2023. The nomination was approved under criterion (x) (Biodiversity and threatened species).

The inscribed property consists of the middle section of Jiangsu Yancheng National Nature Reserve, the Jiangsu Dafeng National Nature Reserve, and the southern section and Dongsha Experimental zone of Jiangsu Yancheng National Nature Reserve, as well as the Tiaozini area totalling 1,886 sq.km. The two wider protected areas – Yancheng Marshes NNR and Dafeng NNR, plus a smaller wetland park and two local nature reserves, total an area of 3,060 sq.km. (Figure 29).

Two additional new regulations have been passed that are crucial to enhance the protection of the property. Inspection teams from the Ministry of Environment ordered that all artificial fishponds inside nature reserves must be abandoned and returned to natural wetlands. The National Forestry and Grassland Administration also issued a ban on the erection of new wind farms along nationally important bird flyways.

A number of concerns for the site remain,<sup>236</sup> including for instance: limited high tide roosting areas for migratory shorebirds;<sup>237</sup> the presence of large numbers of wind farms within nature reserves and offshore; invasive alien *Spartina* cordgrass; intensive onshore developments impacting wintering of Red-crowned Cranes and nesting areas of Saunders's Gulls and the continued development of Tiaozini port.

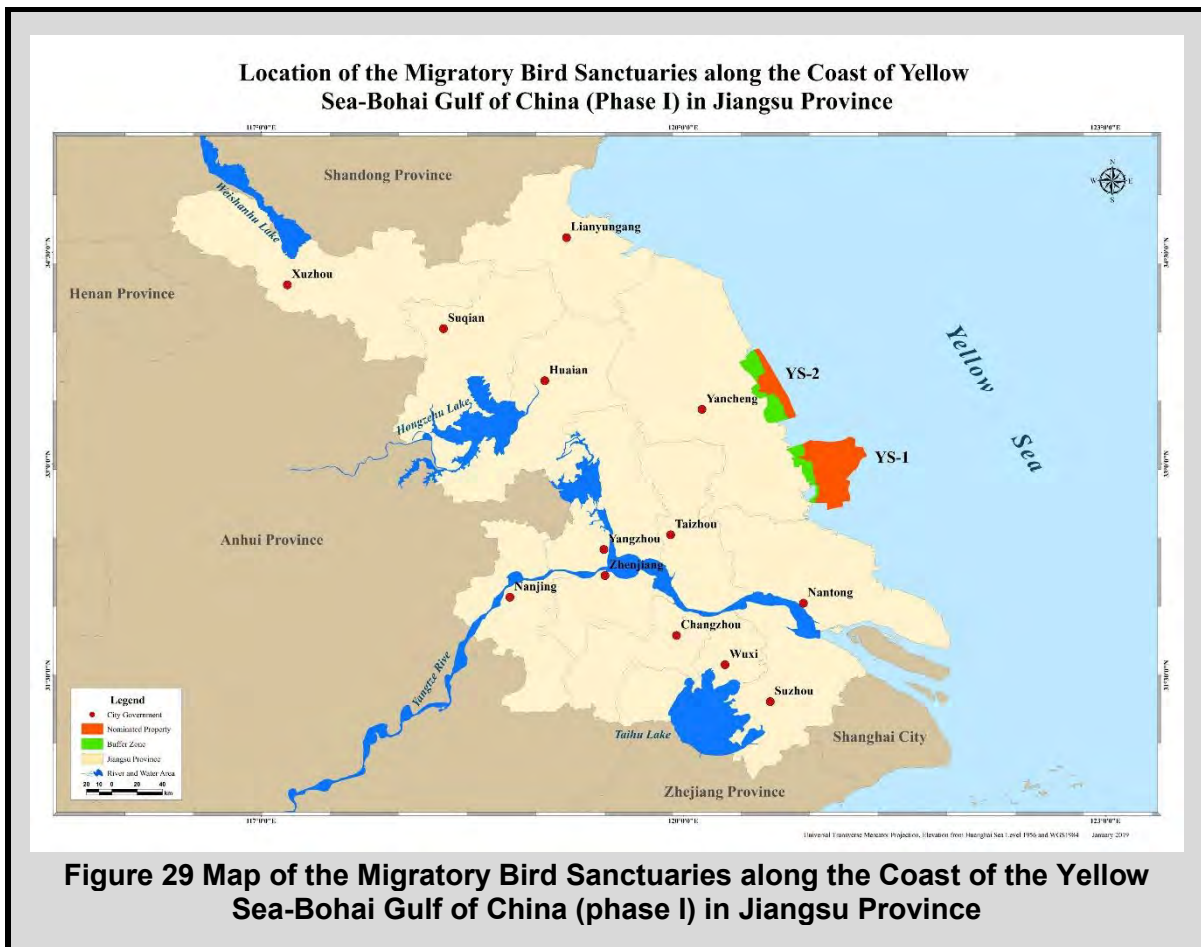
---

<sup>234</sup> Mackinnon et al 2012

<sup>235</sup> [Resolution 028 \(2012\)](#), [Resolution 051 \(2012\)](#), [Resolution 026 \(2016\)](#)

<sup>236</sup> IUCN 2021

<sup>237</sup> Rogers et al. 2006



#### Case Study 4 Serial World Heritage property in ROK

In 2021, the UNESCO World Heritage Committee inscribed the Getbol, Korean Tidal Flats<sup>238</sup> as Phase I of an ROK natural World Heritage serial nomination. The summary for the property's nomination contends the importance of the site.<sup>239</sup>

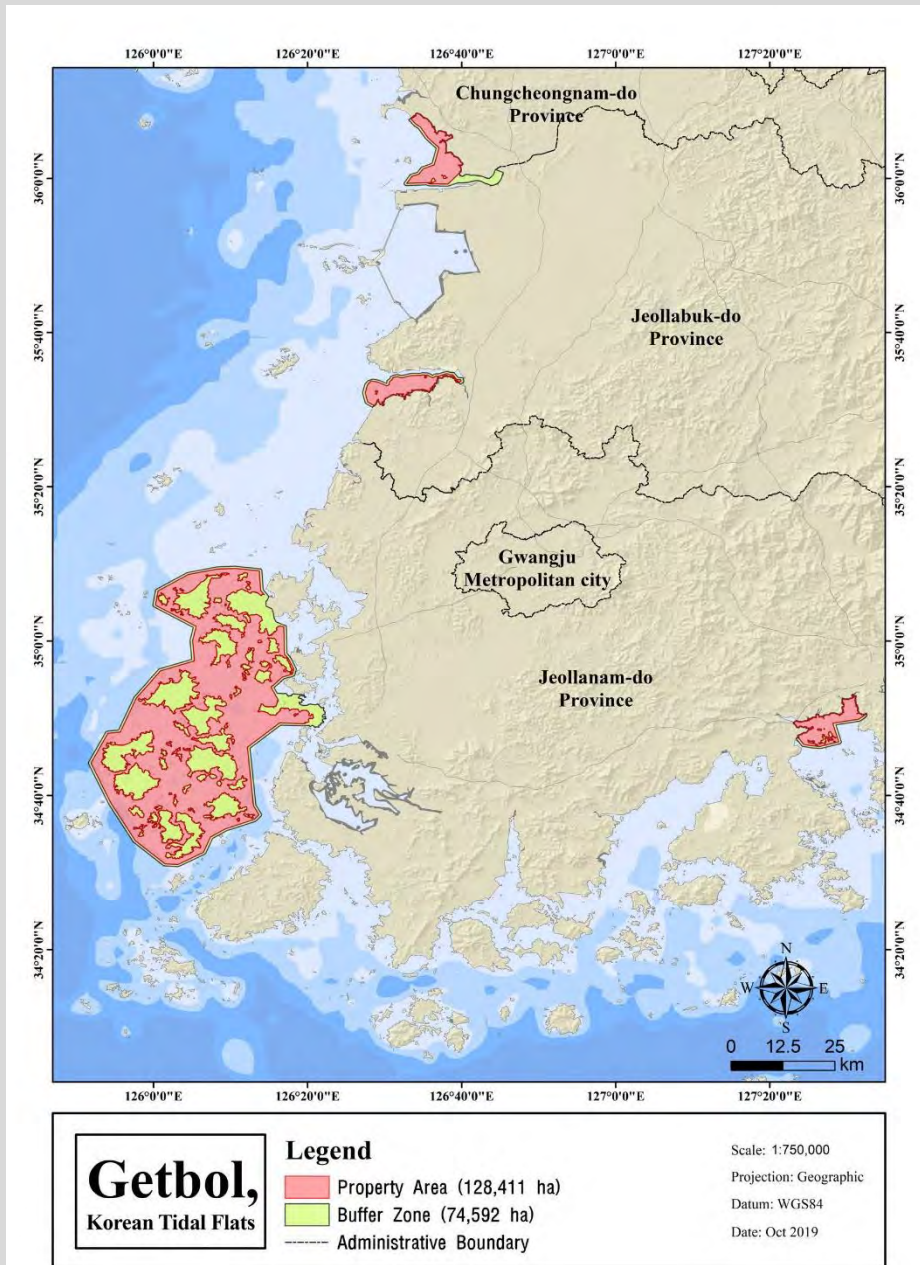
The nominated property is located on the south and west coasts of the Republic of Korea, on the southeastern coast of the Yellow Sea. It is a serial property that was inscribed on the World Heritage List under criterion (x) for its globally significant populations of migratory waterbirds. It is made up of Seocheon Getbol, Gochang Getbol, Shinan Getbol and Boseong-Suncheon Getbol (Table 5, Figure 30). These sites encompass a complex combination of geological, oceanographic and climatic conditions reflecting the island-type (archipelagic) tidal flat ecosystem features, with thousands of islands scattered across an area of >1,000 km<sup>2</sup> (Figure 31Figure 30).

The property is characterized by its high capacity to support 22 endangered waterbird species, including the Spoon-billed Sandpiper (CR on the IUCN Red List), of the EAAF. The various habitats in the property provide the food and space that is much needed for all waterbirds.

<sup>238</sup> World Heritage Committee 2021

<sup>239</sup> Getbol, Korean Tidal Flats, Nomination executive summary

A Phase II nomination is under preparation, which is understood to comprise nine component parts, with a view to being presented to the World Heritage Committee for consideration at its 48<sup>th</sup> session, expected in 2026. Appendix 4 indicates 13 sites of potential relevance for nomination (according to experts consulted by IUCN) including adjacent areas to the four inscribed component parts and key sites for migratory birds in the northern part of the tidal flat complex.



**Figure 30 Topographic map of the Getbol, Korean Tidal Flats Phase 1 World Heritage Sites. © World Heritage Promotion Team of Korean Tidal Flat**

**Table 5 Details of components of the Getbol, Korean Tidal Flats Phase I World Heritage Site**

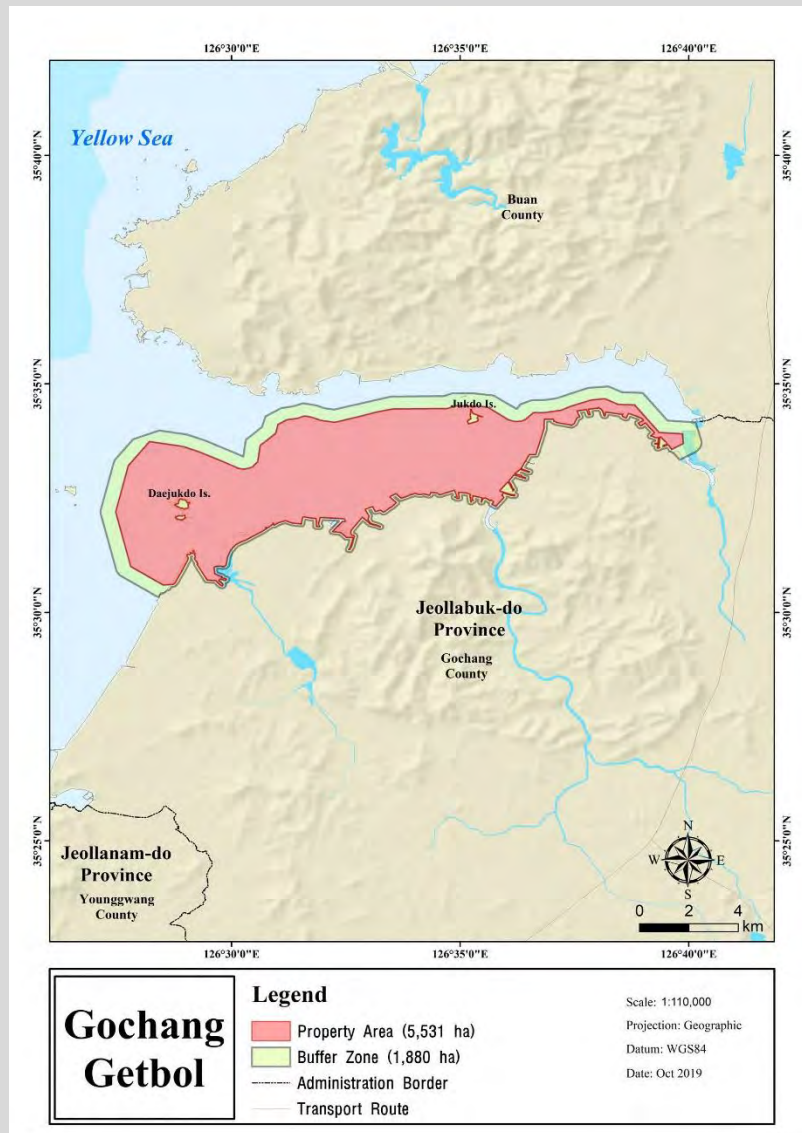
No.	Name of the Component	Region(s) / District(s)	Coordinates of the Central Point	Property Area (ha)	Buffer Zone Area (ha)
1	Seocheon Getbol	Seocheon County	36°02'43.01"N 126°36'46.69"E	6,809	3,657
2	Gochang Getbol	Gochang County	35°33'06.67"N 126°32'01.35"E	5,531	1,880
3	Shinan Getbol	Shinan County	34°49'43.76"N 126°06'16.00"E	110,086	67,254
4	Boseong-Suncheon Getbol	Boseon County, Sunchoen City	34°49'11.25"N 127°27'32.19"E	5,985	1,801
<b>Total Area</b>				<b>128,411</b>	<b>74,592</b>



**Figure 31 Representative scenery of the inner rocky island-type (archipelagic) mud flat in the Getbol, Korean Tidal Flats World Heritage property at Shinan Getbol © World Heritage Promotion Team of Korean Tidal Flat**

## Case Study 5 Gochang Getbol

Gochang Getbol is located on the southwest coast of ROK. The area is a unique ecosystem composed of salt marshes, mudflats, mixed flats, sand flats and rocky substrates.



**Figure 32 Zonation Map of Gochang Getbol © World Heritage Promotion Team of Korean Tidal Flat**

In 2021, it was inscribed as one of the four component parts of the Getbol, Korean Tidal Flats World Heritage property. The Gochang component part covers 5,531 ha hectares with 1,880 ha of buffer zone. In addition, on the 28<sup>th</sup> August 2022, the site was also designated as a Flyway Network Site (FNS) EAAF153, marking the 19<sup>th</sup> FNS in the country.



These new designations complement and strengthen other conservation frameworks on the site, including the Gochang Tidal Flat Wetland Protected Area (2008), Gochang and Buan Tidal Flats Ramsar Site (2010); Gochang UNESCO-MAB Biosphere Reserve (2013) and Gochang Tidal Flat Wetland Protected Area (2018).

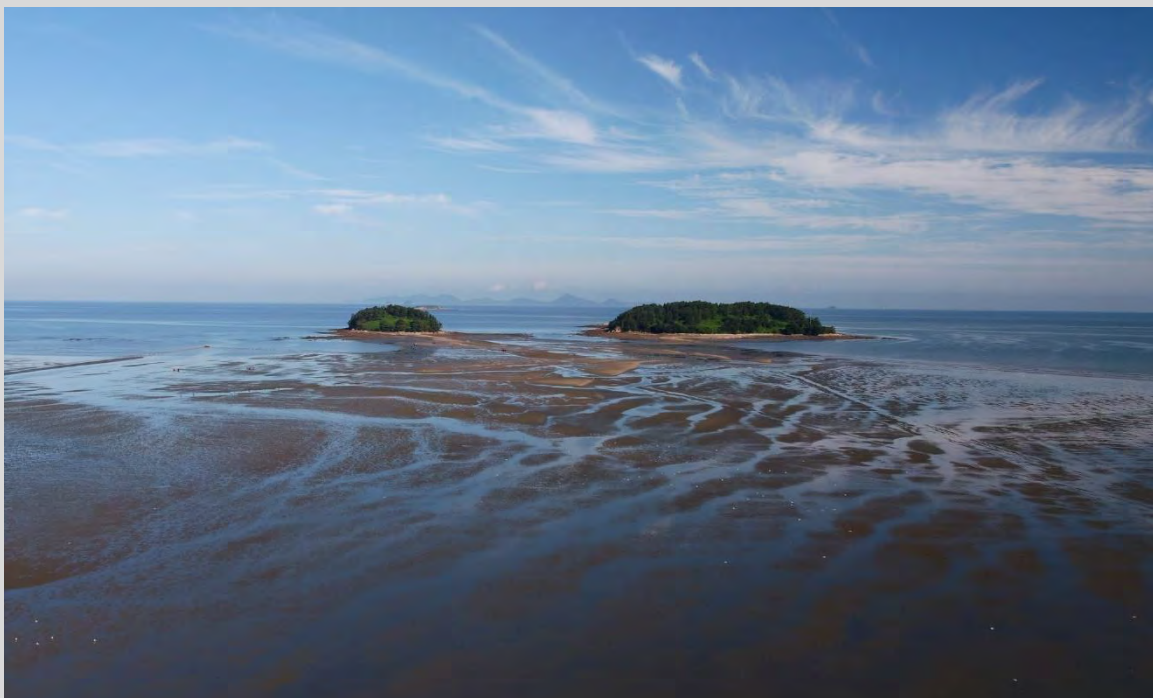
The site regularly supports an average of over 26,000 migratory waterbirds annually, and it is home to 101 species of migratory waterbirds, in which 10 species are globally threatened.

The site supports significant migratory populations of Far Eastern Curlew (EN), Great Knot (EN), Common Pochard (VU), and an increasing number of Black-faced Spoonbill (EN); as well as Oriental Stork (EN), Horned Grebe (VU), Chinese Egret (VU), White-naped Crane (VU), Hooded Crane (VU) and Saunders's Gull (VU) have also been recorded.

Apart from migratory waterbirds, the site is rich and productive for the benthic community, with a total of 255 species of macrobenthos found on the site.

Gochang County has put in place comprehensive CEPA programmes and facilities — The Ramsar Gochang Getbol Visitor Center, which showcases educational programmes and materials, exhibition contents, facilities specialized for school visits and customized ecotourism experiences for visitors.

As part of a World Heritage property and Flyway Network Site, Gochang Getbol is now recognized as a key stopover habitat providing feeding and roosting for numerous migratory waterbirds as they migrate across the EAA Flyway.



**Figure 33 Gochang Getbol © World Heritage Promotion Team of Korean Tidal Flat**

### 7.3 Capacity building

There are a number of initiatives aimed at strengthening both wetland management capacity and capacity on migratory birds and wildlife monitoring throughout the Yellow Sea.

DPRK is working towards establishing a database of wetlands and a Wetland Education Centre, with visual-audio materials and training tools to disseminate knowledge and information through the national intranet. The World Heritage Centre of UNESCO in Paris is also running a training and capacity development programme in DPRK on the management of WH properties. There are various NGOs, including Hanns Seidel Foundation, WWF Hong Kong, IUCN, EAAFP and PūkoROKoro Miranda Naturalists' Trust, that are also providing support and capacity assistance to DPRK, however, more training is needed.

In PRC, WWF Hong Kong has been operating a training programme at the Mai Po Nature Reserve for Chinese wetlands managers over the last 40 years. Many universities and institutes continue to support the development of experts in ornithology, ecology and wetlands management and restoration. In particular, Peking University houses the World Heritage Institute of Training and Research for Asia under the auspices of UNESCO.

The ROK government has established a National Marine Biodiversity Institute of Korea, near the Geum Estuary, which is expected to increase future research and conservation capacity. Additional short-term training and knowledge transfer takes place through numerous workshops and symposia organised by international agencies.

IUCN also has delivered capacity building via WH Leadership, including Phase I Getbol, in ROK. The People-Nature-Culture 2022 course of World Heritage Leadership, in cooperation with the Korea National University of Cultural Heritage and with the support of the Korean Cultural Heritage Administration also visited Gochang Getbol as a capacity-building activity for site managers around the world.

The RRC-EA supported a series of subregional training for Ramsar sites managers in the Yellow sea. These trainings gathered Ramsar Site managers and stakeholders of the Yellow/West Sea representing national and local governments and non-government organizations from PRC, ROK and DPRK. The subregional trainings aimed to orient participants on the basic steps in wetland management; share information and experiences of national government agencies and international organizations; discuss the main challenges of countries in managing the Yellow/West Sea and recommend site-specific and transboundary management strategies to address these challenges.

### 7.4 Growing awareness and attitudes

The 2012 *Situation Analysis*<sup>240</sup> successfully raised awareness about the threats to biodiversity in the Yellow Sea and prompted numerous actions by the three governments at international, regional, national and local levels. The publication also prompted actions by international agencies and domestic NGOs, and led to the development of a growing number of bird-watching societies in the region, and an increased awareness of the Yellow Sea in the media and among the public.

---

<sup>240</sup> Mackinnon et al 2012

At the regional level, IUCN has established the Yellow Sea Working Group (YSWG), which helps to coordinate activities, studies and trans-frontier issues. Partnering together, the YSWG and EAAFP have organized a range of side events, meetings, trainings and activities, mainly in PRC, which have brought together representatives from the three countries, with the support of the international community.

Countries have also made efforts to initiate global and regional platforms and events to raise awareness and support regarding the management of the intertidal wetlands and migratory birds of the Yellow sea. These include the series of Yellow Sea Symposia hosted in Yancheng PRC and regional events held by ROK, such as the 2019 Shinan International Symposium on Conservation Strategy for Migratory Birds and Their Habitats in the Yellow Sea (Case Study 6).

### **Case Study 6 International Yellow Sea Symposia**

#### **a) Yancheng, PRC**

Since Yancheng was included in PRC's Tentative List in 2017, it has developed mechanisms to foster the conservation of coastal wetlands including through enhanced scientific research and sustainable development, hosting annual international conferences on this issue since 2017 (Figure 34).

Following inscription on the World Heritage List in 2019, in 2020, the Yancheng Wetland and Natural World Heritage Conservation and Management Centre and Yellow Sea Wetland Institute were officially established and the fourth Yellow and Bohai Sea Coastal Wetlands Symposium was held. Three joint research centres were also established, including the Nature-based Ecological Restoration Research Center, the Coastal Agriculture Research Institute and the Urban-Rural Integration Development Lab. The research centres will work closely with ministries and national universities.

The 2020 symposium involved 120 representatives from government agencies, research institutes, international organizations, and leading enterprises, whilst another several thousand viewers watched the live stream of the symposium. Topics discussed included Nature-based Solutions, *Spartina* control, feeding and roosting site management, disturbance management, evidence-based sustainable development, and Communication, Capacity Building, Education, Participation and Awareness (CEPA).

The city pledged to become an international wetland city and to regularly host a Global Coastal Forum. Symposium participants agreed to:

- maintain and create a network of multi-functional feeding and roosting sites for migratory waterbirds;
- develop well-coordinated multi-disciplinary research programs and a year-round monitoring scheme;
- establish a Joint China-International Task Team Group to support the work on a Phase II World Heritage nomination pursued by PRC.



**Figure 34 2020 Yellow & Bohai Sea Coastal Wetlands Symposium held in Yellow Sea National Forest Park © Yellow Sea Wetland Institute.**

**b) Shinan, ROK**

The Shinan International Symposium, 12-13 November 2019, with the theme of Conservation Strategy for Migratory Birds and their habitats in the Yellow Sea, was hosted by Shinan County, the Ministry of Oceans and Fisheries, and the Ministry of the Environment of the Republic of Korea. There were approximately 150 participants including various experts, scientists, local stakeholders, wetlands site managers and NGOs, including the Common Wadden Sea Secretariat, EAAFP and the RRC-EA.

The main objectives of this symposium were to promote international research, exchange, and cooperation and to establish an international network for sustainable conservation and protection of intertidal wetlands and migratory birds in the Yellow Sea. In addition, the EAAFP and Shinan County celebrated the designation of Shinan Aphaedo Tidal Flat as an EAAFP Flyway Network Site 146.

In parallel, the 3<sup>rd</sup> meeting of the Yellow Sea Working Group led by IUCN was held to share updates and discuss the Work Plan 2020 – 2022.



**Figure 35 The 2019 Shinan International Symposium. © Shinan County**

At the national level, each of the three countries has developed national movements, such as new policies, citizen science monitoring, World Wetlands Day, World Migratory Bird Day, and the national bird census, which contributes to the annual Asian Waterbird Census, coordinated regionally by Wetlands International. A range of organisations are supporting numerous local-level Communication, Education, Participation and Awareness (CEPA) activities in the Yellow Sea, including International Crane Foundation (ICF), Wildfowl & Wetlands Trust (WWT), Wetlands International, RRC-EA, EAAFP Secretariat, WWF, Hong Kong Birdwatching Society, Paulson Institute, and others (see Appendix 7 for more details).

The Spoon-billed sandpiper, now generally referred to as the ‘Spoony’ has emerged as a lovable icon for Yellow Sea conservation. Many festivals and birding events now take place around the Yellow Sea. Bird Races have emerged as a popular way to celebrate bird diversity and gain new records at the same time.

In **DPRK**, there is an annual waterbird census led by the Academy of Science. Public awareness materials have been produced and education campaigns are conducted to celebrate international environment-related days, including World Wetlands Day, World Migratory Bird Day, International Biodiversity Day and World Environment Day. Mundok NR celebrates an annual Swan Goose Festival and intends to make this an annual event (Case Study 6).

**PRC** has formally adopted an “Ecological Civilization” philosophy, which can serve as an important pathway to promoting wider awareness and attention in non-environmental government sectors. Domestic volunteers form the strength of the important China Coastal Waterbird Census. Following the World Heritage inscription of the Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I), Yancheng NNR in Jiangsu, PRC has become a focal point for many awareness activities and events. PRC celebrates Love Birds Week each year. Hong Kong SAR and Incheon have also established a sisterhood relationship to promote mutual cooperation for the conservation of migratory waterbirds, focusing on the Black-faced Spoonbill. The aim is to share scientific knowledge through joint

research, support education and awareness-raising activities (Figure 36), create wetlands and visitor centres, and share management experiences.

In **ROK**, citizen science monitoring is organized for key species such as the Black-faced Spoonbill and far Eastern Curlew. In 2019, the Eco-Horizon Institute developed an online citizen-monitoring platform called “Getbol Keepers” to assist the monitoring activities of voluntary citizen investigators in Korea and has been regularly conducting a census of migratory waterbirds in 26 areas along the coast of Korea in spring, autumn, and winter. The citizen investigators are trained through the Getbol Keepers Monitoring School. A summary of awareness activities and events is given in Appendix 7.

Boseong-Suncheon Getbol in ROK, part of the Getbol, Korean Tidal Flats World Heritage property (listed as part of the Phase I inscription in 2021) adjacent or overlapping with a Ramsar Site, and EAAFP Flyway Network Site has developed an eco-museum to increase awareness and education. To further protection efforts for internationally endangered waterbirds, Suncheon City has developed a cooperative network with other regions inhabited by cranes, including developing a sisterhood relationship with the City of Izumi, Japan since 2012 for crane protection.

ROK has built visitor centres at several tidal flat sites to inform the public of the importance of the Yellow Sea intertidal wetlands. The centre’s exhibits and educational programmes highlight the ecology and biology of marine organisms and internationally important migratory birds. This has been effective in securing public support for conservation and raising awareness of the value of tidal flats.

The Ministry of Oceans and Fisheries prioritizes the establishment of visitor centres to secure the foundation for management following designation of MPAs. In 2011, MOF also established a Network of Local Visitor Centres of Marine Protected Areas, which currently comprises 22 centres and partner organizations. The network aims to: a) support capacity building of individual centres, b) develop common education programs and materials for the general public, c) support training programs for on-site managers in MPAs, d) promote communication, information exchange, and cooperation among centres, and e) operate programs on international exchange and cooperation. In particular, the network has been working on exchange and cooperation programs with the International Wadden Sea School (IWSS) and has also participated in the Wetland Link International (WLI) Asia-Oceania.



**Figure 36 Black-faced Spoonbill Birthday Party at Namdong Reservoir, ROK. © EAAFP**

### **Case Study 6 Mundok Swan Goose Festival**

Each autumn, approximately a third of the global population of Swan Goose (*Anser cygnoid*) uses the Mundok Migratory Bird Reserve in DPRK as a stop-over site during their southward migration. This important area was designated as a Ramsar site in 2018, and is also an EAAFP wetland site, designated in 1999. There is further potential to add the site to DPRK's Tentative List for potential World Heritage nominations in the near future.

On World Migratory Bird Day on 13 October 2019, the Ministry of Land and Environmental Protection (MoLEP) organised a Swan Goose Festival, together with the EAAFP Secretariat, Hanns Seidel Foundation, WWF-Hong Kong and Hong Kong Bird Watching Society. A total of 160 participants, including international participants, embassy representatives from Russia, Mongolia, and Syria as well as delegates from United Nations (UN) agencies, local government, site managers, and local communities attended this first-ever event.

The opening ceremony included speeches by national leaders, local government representatives and international guests (Figure 37). The Manager of Mundok provided an introduction to the bird reserve. There was also a presentation of a photo exhibition, and a screening of the documentary "Wetlands of Korea, Treasure House of Biodiversity." Participants could simultaneously enjoy inspiring watching the flocks of thousands of Swan Goose and other waterbirds on the tidal flats. Following lunch, WWF-Hong Kong organized environmental education games and operated game booths for children to promote an understanding of food chains, the importance of wetlands and the EAAF.

The festival was planned to be held annually, however since 2020, COVID has prevented this.



**Figure 37 Swan Goose Festival in Mundok Bird Reserve, DPRK. © Vivian Fu/ EAAFP**

## 8 FUTURE OPPORTUNITIES FOR ENHANCING THE PROTECTION, CONSERVATION MANAGEMENT AND RESTORATION OF THE INTERTIDAL ECOSYSTEMS OF THE YELLOW SEA

Although all three countries have taken numerous actions to improve the conservation status and ecological health of the Yellow Sea at the national level, it is clear from this review that there are still significant efforts needed to enhance conservation at the regional level. The following section identifies regional opportunities for improvement. These include action that is required by the decisions of the World Heritage Committee on the respective phase I nominations in PRC and ROK. To ensure that the Outstanding Universal Value of inscribed World Heritage properties is fully preserved, the Operational Guidelines of the World Heritage Convention require States Parties to inform the World Heritage Committee of any intention to undertake in an area protected under the Convention new constructions which may affect the Outstanding Universal Value before making any decisions that would be difficult to reverse, so that the Committee may assist in seeking appropriate solutions.<sup>241</sup> The first part highlights the previously presented threats and their impacts on the ecosystems, and presents possible mitigation measures. The second part discusses some of the proposed protection, conservation management and restoration strategies. The opportunities and strategies are intended as guidance, to be refined and discussed in a national context. Appendix 2 summarises key recommendations.

<sup>241</sup> UNESCO 2021



## Box 7 Enhancing protection, conservation management and restoration<sup>242</sup>

- Improve coastal wetlands governance, including integrated management streamlining and coordinating responsibilities between jurisdictions;
- Review buffer zone design and effectiveness, ensuring that buffer zone regimes mitigate the potential impact of activities in areas surrounding the existing World Heritage properties;
- Ensure that the integrity of all natural attributes of the existing World Heritage properties can be conserved avoiding any negative effects of development projects on the attributes of conservation significance, including any negative effects of wind turbines, pollution (including noise pollution), land reclamation and infrastructure development;
- Ensure rigorous EIA processes with ‘no project’ option, in line with the 2022 IUCN/ICOMOS/ICCROM Guidance and Toolkit for Impact Assessment in a World Heritage context<sup>243</sup>
- Develop and enhance synergies with major international programmes;
- Mainstream needs of coastal wetland biodiversity into more integrated coastal zone planning;
- Enhance synergies between sectors that depend on the health of the Yellow Sea ecosystems;
- Adopt innovative and flexible approaches to conservation to future-proof coastal management;
- Define restoration actions, and Nature-based solutions where needed to improve habitat conditions for migratory birds;
- Improve training of site managers and staff ensuring there are budget lines for ongoing management costs;
- Develop a collaborative mechanism to share management expertise between the three Yellow Sea countries and also with other coastal countries;
- Deploy evidence-based conservation interventions.

---

<sup>242</sup> See also IUCN 2019 and 2021

<sup>243</sup> UNESCO/ICOMOS/ICCROM/IUCN 2022

## 8.1 Review of main threats, drivers, impacts and proposed mitigation measures

Threat description	Drivers	Impacts	Mitigation measures
<p><b>Land claim</b> Approximately 70% of intertidal mudflats have already been lost in land claims. In 2018, PRC announced it will halt ‘business-related’ land claim.<sup>244</sup> Since 2008, ROK Government has declared that it would suspend government-led new large-scale land claim projects.</p>	<ul style="list-style-type: none"> <li>- Perverse incentives e.g. cheaper than converting agricultural lands;</li> <li>- Weak application of laws and regulations.</li> </ul>	<ul style="list-style-type: none"> <li>- The single biggest loss of natural habitat for migrating shorebirds and other waterbirds;</li> <li>- Loss of invertebrates and fisheries;</li> <li>- Loss of blue carbon values and other ecosystem services.</li> </ul>	<ul style="list-style-type: none"> <li>- Prohibit further land claims (e.g. ecological Red Lining);</li> <li>- Include blue carbon and other ecosystem services in EIA;</li> <li>- Extend PA system and stop PA boundary adjustments to reduce areas;</li> <li>- Integrated coastal zone management.</li> </ul>
<p><b>Sea walls</b> Sea walls, or land claim walls, now make up about 30% of the entire YS coastline in all three countries.</p>	<ul style="list-style-type: none"> <li>➤ Countering rising sea levels and coastal erosion.</li> </ul>	<ul style="list-style-type: none"> <li>- Shorter exposure time of remaining tidal flats;</li> <li>- Reduced length of coastline increases energy of tidal erosion;</li> <li>- Enclosed waters no longer tidal.</li> <li>- Salinity changes resulting in prey changes for shorebirds</li> </ul>	<ul style="list-style-type: none"> <li>- Use coastal ecosystems for flood and storm protection, as alternatives to wall construction.</li> <li>- Undertake managed realignment to create more coastal wetland by removing the seal wall, or moving it inland.</li> </ul>
<p><b>Port development</b> Ports are large and continuing to expand. Eight Chinese ports are scheduled to handle the world’s largest vessels including Qingdao,</p>	<ul style="list-style-type: none"> <li>- Pace of economic development and urbanization in YS region. Plans for further development.</li> </ul>	<ul style="list-style-type: none"> <li>- Loss of natural habitat (direct and indirect – changes in hydrology and sediment movement);</li> <li>- Increased shipping disturbance;</li> </ul>	<ul style="list-style-type: none"> <li>- Limit new developments;</li> <li>- Improve the design and operation of ports, including ‘building for nature.’<sup>246</sup></li> </ul>

<sup>244</sup> LT&C 2018

<sup>246</sup> Muller et al. 2020a; 2020b

Threat description	Drivers	Impacts	Mitigation measures
Tianjin, Caofeidian and Lianyungang <sup>245</sup>		- Increased oil leaks and bilge discharge and risk of collision.	
<p><b>Oil extraction</b></p> <p>The Bohai Sea overlies three oil fields: Liaohe, in Liaoning; Shengli, in Tianjin, Hebei and Shandong; and Penglai, offshore in the central Bohai Sea. Oil extraction occurs on land, in the intertidal and offshore.</p>	- High demand and price for energy	<ul style="list-style-type: none"> <li>- Subsidence of land profile;</li> <li>- Changes to tide pattern;</li> <li>- Oil leaks;</li> <li>- Disturbance;</li> <li>- Some loss of habitats.</li> </ul>	<ul style="list-style-type: none"> <li>- Tighten operational standards on oil exploration, production, transport and oil spill responses;</li> <li>- define no-go areas and that all operations outside WH areas do not damage current or potential OUV;</li> <li>- Ensure rigorous EIA processes with 'no project' option for any development projects;<sup>247</sup></li> <li>- Phase out oil fields;</li> <li>- Promote greener energy sources.</li> </ul>
<p><b>Wind farms</b></p> <p>Offshore wind farms are planned in PRC and ROK. There are large wind farms along parts of the Jiangsu and Liaoning coasts and the world's first intertidal wind farms were developed at Rudong. A further 18.5GW of offshore capacity is planned for Jiangsu alone.<sup>248</sup></p>	<ul style="list-style-type: none"> <li>- Demand for energy</li> <li>- Competitive energy pricing</li> </ul>	<ul style="list-style-type: none"> <li>- Hazard to large birds (raptors, spoonbills), large passing flocks and bats;</li> <li>- Wind farms on the intertidal zone can change mudflat behaviour.</li> </ul>	- In PRC: ban new wind farms on red-lined areas – in particular, banning intertidal farms in line with 2019 National Forest and Grassland Administration Circular banning new wind farms from ecologically sensitive areas including of importance for bird migration;

<sup>245</sup> Zhong 2015

<sup>247</sup> UNESCO/ICOMOS/ICCROM/IUCN 2022.

<sup>248</sup> Zhang et al. 2011

Threat description	Drivers	Impacts	Mitigation measures
			<ul style="list-style-type: none"> <li>- In RoK, proposals must follow the 2022 Guidelines for Environmental Assessments of Offshore Wind Power Generation</li> <li>- Improve warning signals (e.g. remove red light component)<sup>249</sup> and temporal operation;</li> <li>- Explore other options to reduce avian collision;</li> <li>- Monitor impacts.</li> </ul>
<p><b>Desalination</b> There is an increasing number of desalination plants for both domestic and industrial supply, with plants now operating in Liaoning, Hebei, Tianjin, Shandong and Jiangsu.</p>	<ul style="list-style-type: none"> <li>- Freshwater shortages.</li> </ul>	<ul style="list-style-type: none"> <li>- Loss of natural habitats;</li> <li>- Hazardous brine piles.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure adequate flow from rivers;</li> <li>- Reduce water wastage.</li> </ul>
<p><b>Aquaculture/ Mariculture</b> Seaweed production in the area was as high as 1.5 million tonnes in 1979 for PRC alone.</p>	<ul style="list-style-type: none"> <li>- High demand and economic pressure</li> </ul>	<ul style="list-style-type: none"> <li>- Loss of natural habitats;</li> <li>- Structures inhibit wild birds;</li> <li>- Introduction of alien species;</li> <li>- Growing conflict between commercial harvesters and wader flocks for target molluscs.</li> </ul>	<ul style="list-style-type: none"> <li>- Set limits, controls, standards and enforce regulations;</li> <li>- Research into shorebird/mollusc aquaculture to promote sustainable management.</li> </ul>

<sup>249</sup> Cook et al.2011

Threat description	Drivers	Impacts	Mitigation measures
<p><b>Overfishing</b> Fishing effort in the YSE already exceeds maximum sustainable yield. Declining catches are evident and there are significant changes in species composition and size of catch.</p>	<ul style="list-style-type: none"> <li>- High demands for seafood</li> </ul>	<ul style="list-style-type: none"> <li>- Declining populations and yields of many economic species;</li> <li>- Competition for resources between countries leads to ill will and reduces ability to cooperate on conservation.</li> </ul>	<p>Ensure implementation of fishing restrictions and closures; e.g.:</p> <ul style="list-style-type: none"> <li>- in PRC, the Bureau of Fisheries of the Ministry of Agriculture and Rural Affairs in the Bohai Sea and Yellow Sea issued strict fishing closures for four months in areas north of 35oN and for 4.5 months in areas south of 35oN, resulting in an 18.4% increase in catch per unit effort (CPUE) from 40.95kg/h in August 2016 to 48.51kg/h in August 2017;</li> <li>- in ROK, a comprehensive no-fishing season for all fishery resources was implemented from April 1 to October 31 in areas of Gunsan and Buan in Jeollabuk province;</li> <li>- restrictions on fishing net mesh size;</li> <li>- implementation of total allowable catch (TAC) regulations;</li> <li>- limiting fishing effort by reducing the number of registered fishing boats;</li> <li>- continuation and extension of the annual fishing closed summer seasons;</li> <li>- supplement the populations of key species via, for example,</li> </ul>

Threat description	Drivers	Impacts	Mitigation measures
			marine ranching, creation of artificial reefs and fish fry release; <ul style="list-style-type: none"> <li>- implement fisheries monitoring plans to allow for the adaptive management of fish stocks.</li> <li>- Better research into, and application of, sustainable yields, quotas, seasons and licensing;</li> <li>- Create "no-take" areas to ensure natural restocking of intertidal and marine fish stocks.</li> <li>- Agreement between the three countries on the level of fish catch and long-term management of the fish stocks.</li> </ul>
<b>Over-harvesting of intertidal invertebrates</b>	<ul style="list-style-type: none"> <li>- High demands for seafood</li> <li>- Harvesting juvenile clams to feed to farmed prawns</li> <li>- Use of more efficient non-traditional harvesting methods</li> </ul>	<ul style="list-style-type: none"> <li>- Growing conflict between commercial harvesters and wader flocks for target molluscs and worms.</li> <li>- Taking large quantities of potential bird foods</li> <li>- Spreading of commercial species,</li> </ul>	<ul style="list-style-type: none"> <li>- Better controls of harvest zones, seasons, quotas and extraction methods;</li> <li>- Create "no-take" areas to ensure natural restocking of intertidal invertebrate stocks.</li> </ul>
<b>Pollution</b> Many dangerous persistent chemicals and objects in the sea and silt are	<ul style="list-style-type: none"> <li>- Rate of industrial development and weak application of safeguards and standards</li> </ul>	<ul style="list-style-type: none"> <li>- Oil spills, plastic waste;</li> <li>- Chemical leaks and discharge;</li> <li>- Eutrophication leading to green and red tides.</li> </ul>	<ul style="list-style-type: none"> <li>- Develop stronger standards;</li> <li>- Tighten pollution control and treatment in agricultural, industrial and urban areas;</li> <li>- Prevent polluted runoff and untreated polluted waters from</li> </ul>

Threat description	Drivers	Impacts	Mitigation measures
entering the food chain and also impacting humans. <sup>250</sup>			entering rivers and coastal/intertidal waters.
<p><b>Invasive alien species</b> Several new invasive species are spreading in the YS Ecosystem but <i>Spartina</i> is the most prolific. It was introduced in Jiangsu, but is now spreading over most of the intertidal zone.</p>	<ul style="list-style-type: none"> <li>- Ill-conceived introductions (e.g. <i>Spartina</i>);</li> <li>- Result of some forms of aquaculture.</li> </ul>	<ul style="list-style-type: none"> <li>- Loss of original intertidal habitats (open flats and <i>Suaeda</i>);</li> <li>- Loss of breeding habitat of Saunders's Gull and other species.</li> </ul>	<ul style="list-style-type: none"> <li>- Urgently develop and implement a complete eradication plan for the invasive alien <i>Spartina</i> grass, from the entire Yellow and Bohai Seas, and other coasts of PRC, ROK and DPRK, based on the most effective prescriptions.</li> <li>- Continue research on most effective method without collateral damage;</li> <li>- Application of better control measures;</li> <li>- Prohibit new introductions and enforce existing bans.</li> </ul>
<p><b>Tourism</b> The domestic tourism market is growing rapidly in PRC and ROK. It is important that tourism and tourism-related revenues are recognised for both their potential positive as well as negative contribution to wetland management.</p>	<ul style="list-style-type: none"> <li>- Growing population and domestic wealth.</li> </ul>	<ul style="list-style-type: none"> <li>- Coastal lands developed for high impact human disturbance;</li> <li>- Unsustainable tourist behaviour such as excessive noise and other activity causing disturbance to wildlife</li> <li>- Litter.</li> </ul>	<ul style="list-style-type: none"> <li>- Improve zoning of tourism activities and facilities;</li> <li>- Improve visitor awareness, appreciation and support of coastal ecosystem importance, sensitivities and conservation;</li> <li>- Limit tourism growth within safe levels.</li> <li>- Follow international guidelines to minimise disturbance to the birds and other wildlife at</li> </ul>

<sup>250</sup> Chen & Reniers 2020

Threat description	Drivers	Impacts	Mitigation measures
			viewing sites including use of screens to allow visitors to access viewing hides unobserved by wildlife and hides designed to provide a clear outlook for visitors with minimal inlook.
<p><b>Hunting, bycatch and poisoning</b> Hunting is a major issue in other parts of EAAF, less so in the YS, but there is some use of mist nets and poison. Bycatch in old fish nets used to protect crops, aquaculture ponds and mollusc spat on tidal flats, plus other fish nets and crab traps. Use of poisons to protect agriculture and fishponds and as source of food items</p>	<ul style="list-style-type: none"> <li>- Easy availability of cheap nets and chemicals and weak law enforcement, combined with low awareness.</li> </ul>	<p>Bird mortality due to:</p> <ul style="list-style-type: none"> <li>- deliberate hunting for food,</li> <li>- deliberate poisoning for food and to protect harvest,</li> <li>- accidental bycatch in nets is likely killing 10s of 1.000s of birds each</li> </ul>	<ul style="list-style-type: none"> <li>- Improve awareness, patrolling and law enforcement;</li> <li>- Control sale of mist nets and dangerous poisons;</li> <li>- Develop fish capture methods that reduce/avoid bycatch of birds.</li> </ul>
<p><b>Declining silt recharge</b> River silt is vital to replenish productivity of the ecosystem. The Yangtze and Yellow River silt flows have declined massively.</p>	<ul style="list-style-type: none"> <li>- Dams on feeder rivers;</li> <li>- Extraction of water upstream.</li> </ul>	<ul style="list-style-type: none"> <li>- Reduction of area of tidal flats;</li> <li>- Declining quality of sediment richness.</li> </ul>	<ul style="list-style-type: none"> <li>- Regular sluicing of dams to release built up silt;</li> <li>- Better control of sand dredging in lake and river beds.</li> </ul>
<p><b>Climate change</b> Global temperatures have risen more than 1.2°C since pre-industrial times, but the rise in the Yellow Sea is about twice the global average and still rising.</p>	<ul style="list-style-type: none"> <li>- Continued reliance on coal and inefficient energy uses, combined with slow transition to renewable energy</li> </ul>	<ul style="list-style-type: none"> <li>- Rising sea levels;</li> <li>- Rising temperatures with consequences for biota;</li> <li>- Changes to salinity and pH;</li> <li>- Increased frequency and severity of extreme weather and typhoons.</li> </ul>	<ul style="list-style-type: none"> <li>- Speed up targets for zero net emission</li> <li>- Improve international cooperation in combatting climate change;</li> <li>- Explore carbon capture.</li> </ul>



## **8.2 Proposed protection, conservation management and restoration strategies**

### *8.2.1 Governance opportunities*

#### **Reduce fragmentation of governance of the coast**

There is room for improvement in all three countries to ensure cohesive governance of the coast, both in terms of national ministries and local governments that share the coastline.

PRC has already greatly streamlined national governance for protecting the natural environment through restructuring and simplifying the roles of different ministries, with all protected area and species conservation, from mountain top to marine, under the jurisdiction of the Ministry of Natural Resources. Similar streamlining would be beneficial in improving coordination between different departments in the other two countries where mandates overlap.

Likewise, it is essential that the relevant local governments that share the coast jointly help develop, and cooperate to deliver, a national strategy for the management of coastal ecosystems. This could be done by appointing an effective agency, directly under the highest authorities, to coordinate and supervise all national, subnational and local government agencies involved in coastal management. Further, countries should establish mechanisms to hold these agencies accountable for ecological losses.

#### **Strengthen Yellow Sea transboundary cooperation**

The Yellow Sea is a single ecosystem, with the migratory birds, fish and other biodiversity as well as geomorphological processes operating irrespective of jurisdictional boundaries. Therefore, the only way to secure the sustainable management of the Yellow Sea coasts is to ensure that the various national and local jurisdictions share a common vision and objectives and share expertise on how best to achieve these.

International collaboration on ecosystem management can also smooth relationships between the jurisdictions. The IUCN-led Yellow Sea Working Group (YSWG) is a good start towards such an approach. It needs to be strengthened to ensure regular meetings that progress a shared mission towards concerted, cooperative action to sustainably manage the Yellow and Bohai Sea coastal ecosystems. In particular, there is an expectation from the international community that the PRC and ROK Yellow Sea WH sites will be managed in synergy. An institutional framework such as a regional coordination committee to foster a cooperative approach needs to be established, evolving from the YSWG.

It is also essential to establish a tripartite agreement on fishing rights and zones in the Yellow Sea as a basis for controlling overfishing and to reduce tensions between competing national fishing fleets. UN agencies may be in the best position to facilitate such agreements.

Yellow Sea governments and partners could continue building on the opportunities provided by global conventions and foras such as the World Conservation Congress, Ramsar and CBD COPs to highlight the value of the Yellow Sea and the need for coordinated action, through side events and resolutions. IUCN WCC Resolution 026 (2016) is, for example, outdated and

a new resolution could be suggested reflecting the progress made in the region as well as the need for further actions and commitments.

### **Strengthen cooperation with the Wadden Sea**

The Common Wadden Sea Secretariat and its Wadden Sea Flyway Initiative have more experience in transboundary management of their shared coastal ecosystem than the Yellow Sea countries. The Wadden Sea Secretariat and Flyway Initiative have been strongly supportive of the World Heritage nomination process in PRC and ROK over the past decade. It is important to strengthen synergies between these two processes, to share lessons from the Wadden Sea about establishing cooperative management of a similar transboundary site and on support for conservation along the flyway.

### **Strengthen concerted cooperative action along the East Asian Australasian Flyway**

The EAAFP fosters cooperation between countries and other stakeholders with the common objective of conserving waterbirds. ROK is the host of the EAAFP Secretariat, PRC is the host of the EAAFP Science Unit and DPRK is now also a partner of the EAAFP.

The EAAFP has the potential to play a stronger role, along the lines of the Wadden Sea Flyway Initiative, through its Yellow Sea Task Force, by engaging the Yellow Sea countries in supporting work along the flyway in line with:

- operative paragraph 7 of UNESCO World Heritage Committee - Decision - 43 COM 8B.3 on PRC's Phase I Yellow Sea inscription: *Encourages all related States Parties in the Flyway to cooperate with each other, in relation to the potential for future transboundary serial nominations, and/or extensions, that more fully reflect the habitat needs and patterns of use of migratory birds along the East Asian Australasian Flyway;*<sup>251</sup> and

- UNESCO World Heritage Committee - Decision - 44 COM 8B.6 on ROK's Phase I inscription: *Encourages the State Party, following Decision 43 COM 8B.3, to further strengthen collaboration with other concerned States Parties to improve the conservation of critical habitats within the Eastern Asian-Australasian Flyway in relation to potential future transnational serial nominations, and/or extensions and, in particular, to coordinate with the State Party of PRC in relation to the anticipated Phase II nomination for Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China, potentially through the 2007 Korea-China Agreement on the Protection of Migratory Birds.*<sup>252</sup>

### **Global engagement on coastal ecosystem conservation**

The YSWG could become a pilot regional hub of the World Coastal Forum (WCF), which has been called for by resolutions and decisions of CMS, Ramsar, CBD and IUCN. Since late 2021 PRC has been enabling its establishment as a direct outcome of the 2019 Yancheng Symposium. Yancheng will host the first WCF conference in the latter part of 2023. This multistakeholder platform supports the implementation of Targets 2 and 3 of the Global Biodiversity Framework. It is a mechanism by which Yellow Sea countries can showcase their

---

<sup>251</sup> UNESCO World Heritage Committee Decision 43 COM 8B.3

<sup>252</sup> UNESCO World Heritage Committee Decision 44 COM 8B.6

successes in coastal ecosystem conservation, and also tap into world class expertise on how to further improve coastal ecosystem practice.

### *8.2.2 Policy and planning opportunities*

There are a number of policy and planning instruments that can be developed and strengthened to support the conservation of the Yellow Sea Ecosystem, including:

- A moratorium on further land claims, with strict enforcement. Countries should also conduct a thorough review of provincial and municipal plans for land claims against the eco-environmental red line or other planning documents.
- Strengthening legislation and its implementation in all three countries to better safeguard coastal wetlands, their biodiversity and ecosystem services.<sup>253</sup>
- Developing oil-spill contingency plans for coastal areas, especially in the Bohai Sea.
- Mainstreaming coastal wetlands and associated ecosystem conservation into regional development planning, in line with imperatives from the CBD and the Global Biodiversity Framework, and strengthening the development of Nature-based Solutions for climate change. Mainstreaming can be achieved through stakeholder inclusion, to promote synergies and harmony among stakeholders.

Rather than seeing development, tourism and fishing as threats and competitors to conservation in the Yellow Sea, countries should explore opportunities for synergies between different sectors and interest groups. For example, there is a lot of overlap of interest between the marine fishing, tourism, mariculture, and mud harvest stakeholders, in that they all rely on a sustainable, biodiverse Yellow Sea Ecosystem. All groups would benefit from curtailing climate change, pollution, invasive alien species and unsustainable fishing.

### **Ensure all strategies and plans for the coast are future-proof**

The intertidal zone will be constantly changing in the future, with climate change, rising sea levels, storms realigning sediments, rivers shifting course, artificially changed flow rates and silt loads impacting the Yellow Sea. It is vital that all strategies and plans for the coast are flexible enough to allow for change, and account for predicted and potential changes related to sea level rise and other climate change related effects, including increased flood risk, and changes to geomorphological processes and sediment flow.

Coastal ecosystems tend to naturally be quite mobile but impacts of sea defences on geomorphology, will require that all strategies and plans for the coast employ flexible forms of protection, and that the implementation of ecosystem restoration and Nature-based Solutions be accelerated.

### *8.2.3 Site protection*

#### **Increase the extent of coastal and marine protected areas**

The loss of Yellow Sea coastal wetland habitat has been significant, therefore, efforts should be made to conserve all remaining natural coastal habitat. A number of gaps have been

---

<sup>253</sup> Ma et al. 2014

identified in the current coverage of protected areas, which is still far from adequate. There is a need to strengthen protection of key sites for migrating shorebirds, especially in PRC at Nanpu, Hebei and Lianyungang, Yangkou and Dongling in Jiangsu Province, and important areas of north-west ROK which are currently unprotected.

The majority of protected areas would be best zoned as general ecosystem reserves, however, others should be selected and designed for specific key species, acting as passage, moulting, wintering and breeding sites for birds, or those that provide resting platforms for Spotted Seals. Additional research is needed to identify sites of importance for a significant number of birds, sites that cater for individual birds throughout their annual and life cycles, and sites that have a high connectivity (the birds which use the site are shared by many countries) ensuring that the boundaries include all areas used by birds both for feeding and roosting at high tide.

It is essential to improve count coverage to help determine key conservation areas. Research is required to understand the estimated turnover of birds during migration periods, and more information is needed to understand how birds use the sites, both within a day, for example moving between feeding and high tide roost sites, and within a year, as individual birds may use several Yellow Sea sites in the course of a year, and more still in the course of their lifetime.

Furthermore, by using connectivity data from bird tracking, ringing recoveries and colour ring resightings, it may be possible to supplement count data as a basis for identification of key sites by determining which sites are most connected along the flyway (for example using network analysis).

### **World Heritage nominations**

All key coastal wetlands and associated habitats of global importance to migratory birds in the Yellow Sea ecosystem could be considered in the serial World Heritage nominations of PRC and ROK.

Similarly, ROK's Phase II WH nomination, due to be submitted in 2026, needs to be comprehensive in coverage of key remaining coastal wetland sites to be in line with the World Heritage Committee's decision.

The recent publication of DPRK's National Wetlands Inventory may also suggest consideration of sites along their Yellow Sea coast for potential addition to their Tentative List. Several international actors are willing to provide support to assist and accelerate such a nomination, including through the aforementioned International Assistance project for the updating of the State Party's Tentative List.

There are also plans in DPRK to establish a protected area network and information system, and integrated coastal zone management system to conserve habitat and preserve biodiversity.

Satellite tagging provides essential data on where birds visit and how they use sites. Moulting Spoon-billed sandpipers rely on sites in DPRK, and satellite tagging should be extended to identify additional priority coastal sites to be added to DPRK's growing list of nature reserves and migratory bird reserves.

## **Consider adapting protected area boundaries in response to ecosystem changes caused by the mobile geomorphology of the Yellow Sea ecosystem and climate change effects**

The highly dynamic Yellow Sea coastal ecosystem presents a significant challenge in terms of defining protected area boundaries. The distribution of intertidal zone and bird site varies with time, therefore decisions on site boundaries that are most appropriate for the current situation, may not be the best solution 20 years in the future. For example, waterbirds will change their behaviour in response to the physical changes of the coastal ecosystem, and therefore the most important habitat for birds may no longer be located within the protected area, and the boundaries will need to be adjusted.

For World Heritage properties, the *Operational Guidelines* of the *World Heritage Convention* enable changes to the boundaries if these changes provide for improved conservation. The mechanisms of significant and minor boundary modifications can be used to improve the integrity and protection of World Heritage properties.

There is also a need for greater flexibility at the national levels. In PRC, for example, the regulations for nature reserves are very restrictive towards expanding boundaries or zones and may need to be reviewed.

### **8.2.4 Site management**

Yellow Sea coastal wetland sites must be actively managed to maintain and enhance their value for birds and other biodiversity. All sites need:

- **Management plans**, at least five years in duration, following internationally agreed upon standards, which account for the contribution of the site to the Yellow Sea Ecosystem, the EAAF and benefits to local communities;
- **Implementation of management plans**;
- **Sufficient budgets for staff to carry out the management activities, build their capacity**, and funding for purchasing infrastructure and equipment.

To maximise conservation benefits, provisions should be made to permit active land management for conservation purposes within the 'core' area of nature reserves.

Consideration should be given to protection with flexible boundaries, or at least zones, which can be applied as and when needed to protect passing bird flocks where the birds decide to settle in any given season. Such 'reserves' could be applied, for example, only in the short critical periods of spring and/or autumn passage and act as an overlay on the normal year-round land uses for other purposes.

### **Management of working coastal wetlands for birds and the local economy**

A range of working coastal wetlands such as shellfisheries, aquaculture and salt pans are very important for waterbirds as feeding, roosting and breeding sites. Regional and global guidance needs to be developed, with help of researchers and support from governments, to support management that provides optimal benefits for both birds and the businesses involved. Also, such guidance is needed for conservation managers who take on such sites

after they have been abandoned by the relevant business, to enable continued suitability for birds.

Salt pans provide valuable habitat for a wide suite of waterbirds including as vital high tide roosts for species that prefer to feed in the intertidal zone as well as providing feeding grounds for birds that prefer brine shrimps.

There are extensive salt pan complexes along the coast of the Yellow and Bohai Sea, for example in PRC, the Nanpu/Luannan coastline and smaller areas in Jiangsu Province. The city of Yancheng was long called Salt City. New saltponds are being constructed in other areas. There are also important salt pans in Namyang in DPRK and Yeonggwang Saltern in ROK.

Fishponds also attract significant numbers of kingfishers, herons, waders, gulls and even ospreys (*Pandion haliaetus*). The raised banks of fishponds are heavily used as high-tide roosts by many waders.

Paddy fields in the region support a range of both birds and aquatic species. At Tiaozini, shorebirds use adjacent paddy fields as high tide roosts. (Furthermore, dry agricultural fields support various species including cranes. For example, inland in Anhui, PRC farmers around Shengjin Lake are subsidised to plant a third annual rice crop but rather than harvesting it, it is left for the wintering Hooded Cranes.)

It is important to learn how best to manage shellfish stocks for both biodiversity and human consumption if future coastal reserve management is to be successful.

The recognition of some of these areas as Other Effective Area-based Conservation Measures (OECM) for migratory waterbird conservation would be relevant to intertidal and supratidal habitat outside PAs of importance to migratory waterbirds. Such sites play a key role for both local livelihoods and biodiversity but do not meet the criteria for designation as protected areas. Incentives for the development of co-management approaches and Nature-based Solutions approach could be explored further.

#### 8.2.5 Restoration

##### **Ecosystem Restoration**

A number of important wetland sites of the Yellow Sea have suffered differing degrees of ecological degradation and are in need of well-planned evidence-based restoration. This may include restoration of natural vegetation, restoration of hydrological regimes, invasive alien species removal, and natural regeneration.

Consideration should be given to managed realignment to restore coastal ecosystems, including for their natural flood defence powers, by moving the sea wall inland, including where the cost of maintenance of sea walls has become prohibitive.

Restoration approaches should also consider the management of infrastructures situated on rivers feeding the Yellow Sea to ensure adequate freshwater and sediment flows in order to restore the area and quality of mudflats.

## Engineering solutions for species

Jackson and Straw<sup>254</sup> have stressed the importance of including high tide roosting sites within coastal protected areas. High tide roost site availability may often be more of a constraint for waterbirds than that of feeding areas, as often land claim has converted all suitable sites, leaving large flocks of birds to fly around, wasting vital energy looking for resting places until the tide goes out and they can resume feeding on the mud flats.

One innovative solution trialled in Australia also piloted with some success at Sol-li tidal flat in the Geum River estuary in ROK, is the use of artificial floating roosts (Figure 38).<sup>255</sup> Alternatively, managers could construct high tide sand spits or roosting dykes. ROK has also secured roosting places for migratory birds through tidal flat restoration projects in Yubudo Island and Gochang tidal flats.

ROK has begun to design resting places for Spotted Seals, providing a novel approach to protecting marine mammals. Similarly, artificial breeding platforms for birds appear to provide benefits for Oriental Storks, which have also begun nesting on electricity pylons, and Black-faced Spoonbills.

A number of protected areas and urban areas support supplementary feeding initiatives during emergencies to help passing flocks of waders stock up on their long journeys. This was implemented at Yalujiang for Great Knots when their natural food supply collapsed. The provisioned food was harvested from other wild tidal mudflats, but future initiatives could be conducted using farmed food sources. As wild habitats continue to shrink and conflicts in land use continue, there may be a need to create artificial feeding sites for passage waders.

Such sites could serve as an ecotourism attraction, bringing income to the site. For example, the artificial feeding of Black-headed Gull (*Chroicocephalus ridibundus*) at the Cuihu Lake in Kunming, Yunnan, PRC has become a thriving tourism sub-industry.

---

<sup>254</sup> Jackson & Straw 2021

<sup>255</sup> BirdLife Australia 2021.



**Figure 38 Far Eastern Curlew (EN) resting on a floating roost. © D. R. Weller**

#### *8.2.6 Strengthening data availability*

There is an urgent need for increased research into shorebird use of the Yellow Sea coast to help inform future resource management decisions. There are still data gaps regarding:

- Shorebird status and distribution;
- Ecological needs of shorebirds – for example their feeding requirements, needs while moulting, and their adaptability to cope with changing conditions;
- The main threats impacting shorebird populations. There is currently a limited understanding of the impacts of chemical pollution, climate change and other factors on invertebrate populations.
- Solutions to address key identified threats. For example, more effective techniques must be developed and tested to control invasive alien species that are negatively impacting the ecosystem.
- Connectivity (using satellite tagging and other measures), phenology and conditions of birds using the Yellow Sea, along the length of the EAAF.<sup>256</sup>

It is important that preference is given to funding research that has a practical application in improving the understanding and management of the Yellow Sea Ecosystem. The findings of this research should be promptly shared and made available to planners and managers. Future decisions impacting the site should be based on sound science, as available through [www.conservationevidence.com](http://www.conservationevidence.com) and through careful supplementary literature reviews as necessary.

Appendix 5 below lists the topics where further research is most urgently needed.

---

<sup>256</sup> Chan et al. 2019



## Development of a monitoring protocol

Many sites around the Yellow Sea coast now undertake monitoring of the numbers at various times of year of migratory shorebird using the sites. It is critical to fill gaps in monitoring, standardise the way observations are reported, and share data between sites and countries. This will enable decision-makers to understand the overall situation in real time and take appropriate measures, such as arranging more in-depth monitoring or halting disturbing activities.

EAAFP could act as a data sharing platform to consolidate and analyse incoming data flow, but improvements need to be in reporting.

Considerable waterbird monitoring is already being conducted by civil society volunteer groups and NGOs, particularly in the PRC. This mobilization of volunteers and use of 'citizen science' needs to be better planned and coordinated so that less popular and non-protected sites are also included in the monitoring. Much of this data is being shared with the Asian Waterbird Census, maintained by Wetlands International. This approach consolidates data from across the Flyway and is essential for updating waterbird population estimates through the EAAF Conservation Status Review, which informs the numerical criteria used by the Ramsar Convention and the EAAFP to identify wetlands of international importance.

Recognising that there are various methods being used for monitoring waterbirds, Wetlands International is working with the Waterbird Monitoring Task Force of the EAAFP to develop standardised methodologies and protocols that will allow for improved monitoring and sharing of information for national, regional and flyway analyses. Within the Yellow Sea, the use of such protocols is essential to inform flyway conservation analyses and prioritise work. Appendix 6 summarises site monitoring needs besides waterbird monitoring.

### 8.2.7 Capacity building

Training is urgently needed, for example, to strengthen the understanding of ecology and wetlands management, application of latest IT technology, satellite tagging, automatic cameras, monitoring and data sharing.

Site managers can receive support, in terms of technical assistance, funds or training, from a number of international programmes, agencies and NGOs (see Appendix 3) to build capacity on management and restoration planning and management.

All three countries have already increased their field staff bird identification skills. Adequate bird guides are available in ROK and PRC but there is no comprehensive bird identification guide in DPRK. This could be easily developed using the new *Guide to Birds of China*, if small funding for translating and printing can be secured.

## 9 CONCLUSION

The 2012 IUCN *Situation Analysis*<sup>257</sup> created alarm and highlighted the need for action to conserve the endangered intertidal zone and associated habitats along the EAAF. This was answered by a strong response by all three countries of the Yellow Sea and partners, which have demonstrated improved conservation. Two new serial World Heritage properties have been put forward and inscribed by UNESCO's World Heritage Committee, which requested Phase II nominations in order to meet integrity requirements. In addition, a number of recent research papers have identified additional sites as conservation priorities for migrating shorebirds and other flora and fauna. Several new nature reserves have also been established, although a number of gaps still remain.

All three countries have increased attention to the conservation of their coastal wetlands, greatly reducing the rates of further coastal land claims and developing new regulations to control the development of wind farms, restore illegal developments and fish farms to natural conditions, eradicate invasive alien species, and regulate littering and pollution. There is evidence that levels of littering and pollution have declined,<sup>258</sup> but many chemicals have long lives and the past damage persists, with intertidal habitats suffering from 'invisible' biodiversity loss.

While it is important to halt coastal land claims, increase the protected areas system and improve levels of protection and conservation management of key sites, this is not sufficient. The populations of migrating shorebirds, marine mammals and fish species continue to decline. There continues to be incidences of green algal blooms, and the extent of floating *Sargassum* weed and tidal *Spartina* grasslands continues to expand, along with blooms of jellyfish.

The Yellow Sea ecosystem remains critically endangered and the inter-tidal habitats continue to decline in area and quality. A wider range of drivers must be tackled if the Yellow Sea ecosystem is to regain ecological health and sustainability. Among these, the loss of riverine silt flowing into the ecosystem, combined with the accelerating effects of climate change, are the most challenging to solve.

There are still a number of questions regarding the most effective approaches to managing the Yellow Sea in the future, particularly under climate change. However, the conservation and restoration of the Yellow Sea coastal wetlands can support effective Nature-based Solutions to climate change.

The Yellow Sea is a classic example of the shared commons, with three countries sharing the same waters and biotic resources, and each contributing to the continued pollution and overuse of the area, unable to provide the urgent remedial actions needed unless the other two countries are acting in harmony. Even a clear division of national jurisdiction and sovereignty of the sea space is not enough, as the water flows across such lines and the fish, birds and other biota move back and forth regardless of jurisdictional boundaries. It is vital to

---

<sup>257</sup> Mackinnon et al 2012

<sup>258</sup> UNDP 2020

build mechanisms and instruments by which the three countries can agree on the issues and their respective roles in applying solutions.

In addition, the ecosystem is connected to the wider region. Sea currents flow into the Yellow Sea from the Pacific Ocean, and climate and sea levels are affected by the activities of the entire global community. The nature of migratory species requires conservation within the territory of numerous nations, especially those along the EAAF. The three countries directly concerned with the Yellow Sea must therefore be active in using wider global and international programs and conventions to secure the best possible assistance and agreements with the rest of the world, especially in relation to tackling climate change, pollution of the marine environment and the spread of alien species.

There is great potential synergy between several economic sectors that all depend on maintaining a healthy and productive Yellow Sea ecosystem – fisheries, mariculture, tourism, public health and efforts to contain climate change. Conservation agencies should take advantage of these synergies and ensure that their own plans and needs are integrated into wider sectoral and regional plans, including the delivery of Nature-based Solutions.

Success is dependent on the adoption of a broader range of integrated and innovative protection, management and restoration approaches and synergies between the various sectors that are dependent on a healthy Yellow Sea Ecosystem, including conservationists, fishers, aquaculture farmers, health workers and the tourism industry. Success will also depend on much greater levels of international goodwill and cooperation between the three countries sharing the same resources and facing the same problems and on the willing help of the many international partners passionate to help.

Broader programmes and alliances such as the EAAFP, Ramsar Convention, World Heritage Convention, IUCN's Yellow Sea/West Sea Working Group, the ADB Regional Flyway Initiative, and the emerging World Coastal Forum offer opportunities for all three countries to coordinate activities with each other and with other coastal nations.

Efforts to conserve biodiversity and especially migratory waterbirds will further benefit if they are integrated with other broad initiatives. These include initiatives on climate change adaptation, Convention on Biological Diversity, Convention on Migratory Species, marine conservation initiatives, Law of the Sea negotiations, the new World Heritage programme for transboundary and regional cooperation for natural and mixed World Heritage sites in Asia, World Health Organization programmes, the UNDP Yellow Sea projects, and the site-specific and regional projects of several international NGOs specializing in conservation of wetlands and water birds.

All actions and initiatives still rely on increased publicity and awareness raising directed at local communities, the general public, government planners and officials as well as businesses for which sustainable management of coastal ecosystems provides benefits. The academic community can support research to ensure that plans and conservation interventions are firmly evidence-based and based on the most recent scientific data from ground truth measures combined with remote sensed monitoring.

In the decade since the 2012 IUCN Situation Analysis, the tremendous progress which the Yellow Sea countries have made in coastal wetland conservation has been a source of

optimism and inspiration far beyond their shores, and indeed beyond the EAAF. In another decade's time, when the world assesses its success in meeting the targets of the 2022 Kunming-Montreal Global Biodiversity Framework, the hope is that through expanding on their recent successes, the Yellow Sea countries will be seen to have excelled, not only regionally, but through influence along the EAAF and globally. The measure of success will be recovery of the migratory waterbird populations that for now are still classified as globally threatened. The birds are the sentinels of how sustainably we manage the coastal wetlands which we share with them.

## 10 REFERENCES

- 4COffshore. (2021) Yeonggwang Chilsan Offshore Wind Farm.  
<https://www.4coffshore.com/windfarms/south-korea/yeonggwang-chilsan-south-korea-kr67.html>
- Amano, T., Székely, T., Koyama, K., Amano, H. & Sutherland, W.J. (2010) A framework for monitoring the status of populations: An example from wader populations in the East Asian-Australasian flyway. *Biological Conservation* 143: 2238-2247.  
<https://doi.org/10.1016/j.biocon.2010.06.010> ; see also 2012 addendum: *Biological Conservation* 145: 278-295. <https://doi.org/10.1016/j.biocon.2011.06.006>
- Arias, A.H., Vazquez-Botello, A., Tombesi, N. et al. Presence, distribution, and origins of polycyclic aromatic hydrocarbons (PAHs) in sediments from Bahía Blanca estuary, Argentina. *Environ Monit Assess* 160, 301–314 (2010).  
<https://doi.org/10.1007/s10661-008-0696-5>
- Associated Press. (2021). Israel works to contain avian flu outbreak as thousands of migrating cranes die. Canadian Broadcasting Corporation.  
[<https://www.cbc.ca/news/health/bird-flu-kills-thousands-cranes-israel-1.6299683>]  
(Accessed: 12 July 2022)
- Bai, Q.Q., Chen, J.Z., Chen, Z.H., Dong, G.T., Dong, J.T., Dong, W.X., Fu, V.W.K., Han, Y.X., Lu, G., Li, J., Liu, Y., Lin, Z., Meng, D.R., Martinez, J., Ni, G.H., Shan, K., Sun, R.J., Tian, S.X., Wang, F.Q., Xu, Z.W., Yu, Y.-T., Yang, J., Yang, Z.D., Zhang, L., Zhang, M. & Zeng, X.W., China Coastal Waterbird Census Group. (2015) Identification of coastal wetlands of international importance for waterbirds: a review of China Coastal Waterbird Surveys 2005–2013. *Avian Research* 6, 12.  
<https://doi.org/10.1186/s40657-015-0021-2>
- Bamford, D., Watkins, D., Bancroft, W., Tischler, G. & Wahl, J. (2008) *Migratory shorebirds of the East Asian - Australasian Flyway: Population estimates and internationally important sites*. Wetlands International – Oceanea, Canberra, Australia.
- Barter, M.A., Wilson, J.R., Li, Z.W., Dong, Z.G., Cao, Y.G. & Jiang, L.S. (2000) Yalu Jiang National Nature Reserve, north-eastern China – a newly discovered internationally important Yellow Sea site for northward migrating shorebirds. *Stilt* 37: 14-20.
- Barter, M. (2002) *Shorebirds of the Yellow Sea – Importance, Threats and Conservation Status*. Global Series 9, International Wader Studies 12, Canberra, Australia.  
<http://www.deh.gov.au/biodiversity/migratory/waterbirds/yellow-sea/index.html>.
- Bartholdy, J. & Aagaard, T. (2012) Storm surge effects on a back-barrier tidal flat of the Danish Wadden Sea. *Geo-Marine Letters* 20:133-141. DOI: 10.1007/s003670000048
- Bellini, E. (2021) Korean group to deploy 200 MW of floating PV at Saemangeum tidal flats. *PV magazine*. Published Sep 21 2021. <https://www.pv-magazine.com/2020/09/21/korean-group-to-deploy-200-mw-of-floating-pv-at-saemangeum-tidal-flats/>

- Berzin A., Ivashchenko, V.Y., Clapham, J.P. & Brownell, L.R.Jr. (2008) The Truth About Soviet Whaling: A Memoir. <https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1014&context=usdeptcommercepub>
- BirdLife Australia (undated) Geum estuary project – floating roost trial. (2021) <http://geum.birdlife.org.au/floating-roost-trial>
- BirdLife International. (2021) IUCN Red List for birds. <https://www.birdlife.org/projects/iucn-red-list/>
- Birds Korea (2010) *The Birds Korea Blueprint for the conservation of Avian Biodiversity in the South Korean part of the Yellow Sea*. <http://www.birdskorea.org/Habitats/YSBR/Downloads/Birds-Korea-Blueprint-2010.pdf>
- Bugnot, A. B., Mayer-Pinto, M., Airoidi, L., Heery, E.C., Johnston, E.L., Critchley, L.P., Strain, E.M.A., Morris, R.L., Loke, L.H.L., Bishop, M.J., Sheehan, E.V., Coleman, R.A. & Dafforn, K.A. (2021) Current and projected global extent of marine built structures. *Nature Sustainability* 4: 33–41 <https://doi.org/10.1038/s41893-020-00595-1>
- Byrne, L. (2015). 'North Korea investigating tidal power.' NK News. [<https://www.nknews.org/2015/05/north-korea-investigating-tidal-power/>] Accessed: 3 September 2022.
- Byun, G-H., Moon, H-B., Choi, J-H., Hwang, J., & Kang, C-K. (2013) Biomagnification of persistent chlorinated and brominated contaminants in food web components of the Yellow Sea. *Marine Pollution Bulletin* 73: 210–219. <https://doi.org/10.1016/j.marpolbul.2013.05.017>
- Cang A. & A. Koh. (2021). 'Oil Oil Tanker Leaks Cargo Into Ocean Near China's Refining Hub.' Bloomberg. [[bloomberg.com/news/articles/2021-04-27/tanker-spills-oil-into-yellow-sea-off-china-s-key-refining-port](https://www.bloomberg.com/news/articles/2021-04-27/tanker-spills-oil-into-yellow-sea-off-china-s-key-refining-port)] (Accessed 5 Aug 2022)
- CBD. 2016. 5th National Report on Biodiversity of DPR Korea. <https://www.cbd.int/doc/world/kp/kp-nr-05-en.pdf>.
- CBD. 2020. Country Profiles: Democratic People's Republic of Korea. <https://www.cbd.int/countries/profile/?country¼kp>.
- Chang, Q., Ki, T., Anderson, G., Brides, K., Clark, N., Ding, J., Leung, K., Li, J., Melville, D., Philips, J., Weston, E., Yang, Z., & Green, R. (2021) Numbers of Spoon-billed Sandpipers in Jiangsu Province, China, during the post-breeding moult in relation to recent changes in the intertidal zone. *Wader Study* 128: 125–136. <https://doi.org/10.18194/ws.00233>
- Chang, T.S., Ha, H.J. & Chun, S.S. (2015) Factors controlling mud accumulation in the Heuksan mud belt off southwestern Korea. *Geo-Marine Letters* 35: 461-473. DOI 10.1007/s00367-015-0421-7

- Chan, Y.-C., Peng, H.-B., Han, Y.-X., Chung, S.-S.-W., Li, J., Zhang, L. & Piersma, T. (2019) Conserving unprotected important coastal habitats in the Yellow Sea: shorebird occurrence, distribution and food resources at Lianyungang. *Global Ecology and Conservation* 20: e00724. <https://doi.org/10.1016/j.gecco.2019.e00724>
- Chen, C. & Reniers, G. 2020. Chemical industry in China: The current status, safety problems, and pathways for future sustainable development. *Safety science*, 128, p.104741.
- Chen, Y., Dong, J., Xiao, X., Ma, Z., Tan, K., Melville, D., Li, B., Lu, H., Liu, J. & Liu, F. (2019) Effects of reclamation and natural changes on coastal wetlands bordering China's Yellow Sea from 1984 to 2015. *Land Degradation & Development* 30: 1533-1544. DOI: 10.1002/ldr.3322
- Choi, C.-Y., Battley, P.F., Potter, M.A., Ma, Z., & Liu, W. (2014) Factors affecting the distribution patterns of benthic invertebrates at a major shorebird staging site in the Yellow Sea, China. *Wetlands* 34: 1085-1096. DOI 10.1007/s13157-014-0568-4
- Choi, C.-Y., Battley, P.F., Potter, M.A., Rogers, K.G. & Ma, Z. (2015) The importance of Yalu Jiang coastal wetland in the north Yellow Sea to Bar-tailed Godwits *Limosa lapponica* and Great Knots *Calidris tenuirostris* during northward migration. *Bird Conservation International* 25: 53-70. doi:10.1017/S0959270914000124
- Choi, C.-Y., Battley, P.F., Potter, M.A., Ma, Z., Melville, D.S & Sukkaewmanee, P. (2017) How migratory shorebirds selectively exploit prey at a staging site dominated by a single prey species. *Auk* 134: 76-91. DOI: 10.1642/AUK-16-58.1
- Choi, C. Y., Jackson, M.V., Gallo-Cajiao, E., Murray, N.J., Clemens, R.S., Gan, X. & Fuller, R.A. (2018) Biodiversity and China's new Great Wall. *Diversity and Distributions* 24: 137-143. DOI: 10.1111/ddi.12675
- Choi, C.Y., Shi, X., Shi, J.B., Gan, X.J., Wen, C.J., Zhang, J.W., Jackson, M.V., Fuller, R.A. & Gibson, L. (2022) China's Ecological Conservation Red Line policy is a new opportunity to meet post 2020 protected area targets. *Conservation Letters* 15 : e12853. DOI: 10.1111/conl.12853
- Choi, C.-Y., Li, J. & Xue, W.J. (2020a) *China Coastal Waterbird Census Report (Jan. 2012–Dec. 2019)*. Hong Kong Bird Watching Society, Hong Kong.
- Choi, H.-A., Seliger, B., Moores, N., Borzée, A. & Yoon, C.H.K. (2020b) Avian surveys in the Korean Inner Border area, Gimpo, Republic of Korea. *Biodiversity Data Journal* 8: e56219. <https://doi.org/10.3897/BDJ.8.e56219>
- Choi, K.-H., Kim, J.-H., & Shin, S.-Y. (2016) Exodus of investors picks up at Saemangeum. *Korea JoongAng Daily newspaper* 6 June 2016. <https://koreajoongangdaily.joins.com/news/article/Article.aspx?aid=3019673>
- Choi, Y. R. (2014) Modernization, development and underdevelopment: Reclamation of Korean tidal flats, 1950s–2000s. *Ocean & Coastal Management* 102: 426-436. <https://doi.org/10.1016/j.ocecoaman.2014.09.023>

- Chong, J.R., Pak, U.I., Rim, C.Y. & Kim, T.S. (1996) Breeding biology of Black-faced Spoonbill *Platalea minor*. *Strix* 14: 1-10.
- Chuai, X., Huang, X., Wang, W., Zhao, R., Zhang, M., & Wu, C. (2015) Land use, total carbon emissions change and low carbon land management in coastal Jiangsu, China. *Journal of Cleaner Production* 103: 77-86. DOI: 10.1016/j.jclepro.2014.03.046
- Chun, S.S., Yang, B.C., Kim, J.K. & Baek, Y.S. 2004, Comparison in depositional characteristics and preservation potential between winter storm and summer typhoon deposits in the open-coast tidal-flat setting, 5th Int'l. Conf. on Asian Marine Geology and IGCP-475 Delta Map, Bangkok, Thailand, Jan. 13-18 2004, Proceedings, p.37-38.
- Conklin, J.R., Lisovski, S. & Battley, P.F. (2021) Advancement in a long-distance bird migration through individual plasticity in departure. *Nature Communications* 12: 4780 doi.org/10.1038/s41467-021-25022-7
- Conklin, J.R., Lok, T., Melville, D.S., Riegen, A.C., Schuckard, R., Piersma, T. & Battley, P.H. (2016) Declining adult survival of New Zealand Bar-tailed Godwits during 2005-2012 despite apparent population stability. *Emu* 116: 147-157. <https://doi.org/10.1071/MU15058>
- Conklin, J.R., Verkuil, Y.I. & Smith, B.R. (2014) *Prioritizing Migratory Shorebirds for Conservation Action on the East Asian-Australasian Flyway*. WWF-Hong Kong, Hong Kong
- Cook, A.S.C.P., Ross-Smith, V.H., Roos, S., Burton, N.H.K., Beale, N., Coleman, C., Daniel, H., Fitzpatrick, S., Rankin, E., Norman, K. & Martin, G. (2011) *Identifying a range of options to prevent or reduce avian collision with offshore wind farms using a UK-based case study*. BTO Research Report No. 580. British Trust for Ornithology, Thetford, UK.
- Davidson, N. C., Finlayson, M. & McInnes, R. (2019) Worth of wetlands: Revised global monetary values of coastal and inland wetland ecosystem services. *Marine and Freshwater Research* 70: 1189-1194. Doi.org/10.1071/MF18391
- Ding, Z. W., Zhang, S. P., Bai, H., Xue, D. Q., & Zhou, X. S. (2011) Identification of the beginning of the sea-fog season over Yellow Sea and its annual variation. *Periodical of Ocean University China* 41: 11–18. [In Chinese]
- DPRK. 2016. 5th National Report on Biodiversity to the CBD.
- Duan, H.L., Yu, X.B., Xia, S.X. & Liu, Y. (2022) Conserving unprotected important sites for shorebirds on China's coasts. *Ecosphere* 13: e3950. <https://doi.org/10.1002/ecs2.3950>
- Du, H. H., Kong, L. D., Cheng, T. T., Chen, J. M., Du, J. F., Li, L., Xia, X., Leng, C. P. & Huang, G. H. (2011) Insights into summertime haze pollution events over Shanghai based on online water-soluble ionic composition of aerosols. *Atmospheric Environment* 45: 5131–5137. <https://doi.org/10.1016/j.atmosenv.2011.06.027>



- EAAFP (2016) <https://www.eaaflyway.net/2016/08/05/the-yellow-sea-the-highest-conservation-priority-in-east-asia/>
- EAAFP (2021) “Getbol, Korean Tidal Flats” inscribed on UNESCO World Heritage List. [https://www.eaaflyway.net/getbol\\_korean-tidal-flats\\_inscribed\\_unesco-whs/](https://www.eaaflyway.net/getbol_korean-tidal-flats_inscribed_unesco-whs/)
- Edmonds, D. A., Caldwell, R.L., Brondizio, E.S. & Siani, S.M.O. (2020) Coastal flooding will disproportionately impact people on river deltas. *Nature Communications* 11: 4741. <https://doi.org/10.1038/s41467-020-18531-4>
- EFSA (European Food Safety Authority), ECDC (European Centre for Disease Prevention and Control), EURL (European Reference Laboratory for Avian Influenza), Adlhoch, C., Fusaro, A., Gonzales, J.L., Kuiken, T., Marangon, S., Niqueux, É., Staubach, C., Terregino, C., Lima, E., Muñoz Guajardo, I. & Baldinelli, F. (2021) Scientific report: Avian influenza overview December 2020 – February 2021. *EFSA Journal* 19: 6497, 74 pp. doi:10.2903/j.efsa.2021.6497
- FAO. (2022). Global Avian Influenza Viruses with Zoonotic Potential Situation Update. [<https://www.fao.org/animal-health/situation-updates/global-aiv-with-zoonotic-potential/en>] (Accessed: 12 July 2022)
- Feng, H., Grifoll, M., Yang, Z. & Zheng, P. (2021) Latest challenges to ports in public-private partnership: case of Dandong Port (China)’s bankruptcy. *Transport Policy* 110: 293-305. <https://doi.org/10.1016/j.tranpol.2021.06.011>
- Feng, L., Zhu, X. & Sun, X. (2014) Assessing coastal reclamation suitability based on a fuzzy-AHP comprehensive evaluation framework: a case study of Lianyungang, China. *Marine Pollution Bulletin* 89: 102-111. <https://doi.org/10.1016/j.marpolbul.2014.10.029>
- Flemming, B.W. (2005) Tidal environments. In: Scharztz M (ed) *Encyclopedia of coastal science*. Springer, Berlin (pp 1180-1185).
- Flemming, S.A., Lanctot, R.B., Price, C., Mallory, M.L, Kuhn, S., Drever, M.C., Barry, T. & J.F. Prevencher. (2022) Shorebirds ingest plastics too: what we know, what we do not know, and what we should do next. *Environmental Reviews*. 30(4): 537-551. <https://doi.org/10.1139/er-2022-0008>
- Gan, X. (2023) An Overview of China's Policy on Spartina Control. EAAFlyway. <https://www.eaaflyway.net/china-policy-on-spartina-control/>
- Gao, S., Du, Y.F., Xie, W.J., Gao, W.H., Wang, D.D. & Wu, X.D. (2014) Environment-ecosystem dynamic processes of *Spartina alterniflora* saltmarshes along the eastern China coastlines. *Science China: Earth Sciences* 57: 2567–2586, doi: 10.1007/s11430-014-4954-9
- Greenpeace. (2010). Dalian Oil Spill: Preliminary Findings and Recommendations. [<https://web.archive.org/web/20100805232029/http://www.greenpeace.org/china/en/press/release/dalian-oil-recommendations-steiner>] (Accessed 21 August 2022)

- Green, R.E., Syroechkovskiy, E.E., Anderson, G.Q.A., Aung, P.P., Chang, Q., Chowdhury, S.U., Clark, J.A., Foysal, M., Gerasimov, Y., Hughes, B., Kelly, C., Lappo, E., Lee, R., Leung, K.K.S., Li, J., Loktionov, E.Y., Melville, D.S., Phillips, J., Tomkovich, P.S., Weston, E., Weston, J., Yakushev, N., Zöckler, C. & Clark, N.A. (2021) New estimates of the size and trend of the world population of the Spoon-billed Sandpiper using three independent statistical models. *Wader Study* 128: 22-35.  
Doi:10.18194/ws.00218
- Grung, M., Lin, Y., Zhang, H., Steen, A.O., Huang, J., Zhang, G., & Larssen, T. (2015). Pesticide levels and environmental risk in aquatic environments in China — A review. *Environment International* 81: 87–97. <https://doi.org/10.1016/j.envint.2015.04.013>
- Han, I.S., & Lee, J.S. (2020) Change the annual amplitude of sea surface temperature due to climate change in a recent decade around the Korean Peninsula. *Journal of the Korean Society of Marine Environment & Safety Research Paper* 26: 233-241. <https://doi.org/10.7837/kosomes.2020.26.3.233>
- Healy, T., Wang, Y. & Healy, J.-A. (eds.). 2002. *Muddy Coasts of the World*. Elsevier Science B.V.
- Higgins, S., Overeem, I., Tanaka, A. & Syvitski, J.P.M. (2013) Land subsidence at aquaculture facilities in the Yellow River delta, China. *Geophysical Research Letters* 40: 3898-3902. doi:10.1002/grl.50758 2013
- Hooijer, A., & Vernimmen, R. (2021) Global LiDAR land elevation data reveal greatest sea-level rise vulnerability in the tropics. *Nature Communications* 12, 3592. <https://doi.org/10.1038/s41467-021-23810-9>
- Hou, X.Y., Wu, T., Hou, W., Chen, Q., Wang, Y.D. & Yu, L.J. (2016) Characteristics of coastline changes in mainland China since the early 1940s. *Science China: Earth Sciences* 59: 1791–1802. <https://doi.org/10.1007/s11430-016-5317-5>
- Huang, J., Yin, Y., Xu, J. & Zhu, X. (2008) Spatial distribution features and environment effect of heavy metal in intertidal surface sediments of Guanhe estuary, Northern Jiangsu Province. *Frontiers of Earth Science in China* 2: 147-156. DOI 10.1007/s11707-008-0033-x
- Huang, Y.G., Yang, H.F., Jia, J.J., Li, P., Zhang, W.X., Wang Y.P., Ding, Y.F., Dai, Z.J., Shi, B.W. & Yang, S.L. (2022) Declines in suspended sediment concentration and their geomorphological and biological impacts in the Yangtze River estuary and adjacent sea. *Estuarine, Coastal and Shelf Science* 265: 107708. <https://doi.org/10.1016/j.ecss.2021.107708>
- Hu, L., Shi, X.F., Bai, Y.Z., Qiao, S.Q., Li, L., Yu, Y.G., Yang, G., Ma, D.Y. & Guo, Z.G. (2016) Recent organic carbon sequestration in the shelf sediments of the Bohai Sea and Yellow Sea, China. *Journal of Marine Systems* 155:50-58. <https://doi.org/10.1016/j.jmarsys.2015.10.018>
- Hu, R., Ye, J.S. & Qi, Y.L. (2021) Impact and harm mitigation of offshore wind farms on birds. *Southern Energy Construction* 8: [in Chinese]

[https://www.energychina.press/fileNFNYJS/journal/article/nfnyjs/2021/3/PDF/2095-8676\(2021\)03-0001-07.pdf](https://www.energychina.press/fileNFNYJS/journal/article/nfnyjs/2021/3/PDF/2095-8676(2021)03-0001-07.pdf)

- Hwang, Y.; Park, S.; Park, G.; Choi, S.; Kim, M. (2010). Total arsenic, mercury, lead, and cadmium contents in edible dried seaweed in Korea. *Food Addit. Contam. Part B* 3, 7–13.
- Hynd, A.M. (2016) When Chinese fishermen become ‘pirates’ in the Yellow Sea. <https://thediplomat.com/2016/10/when-chinese-fishermen-become-pirates-in-the-yellow-sea/>
- IPCC (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R. & B. Zhou, B. (eds.)]. Cambridge University Press, Cambridge.
- IPCC (2022) *Climate Change 2022 - Impacts, Adaptation and Vulnerability*. <https://www.ipcc.ch/report/ar6/wg2/>
- IUCN (2016) <https://portals.iucn.org/library/sites/library/files/documents/iucn-wcc-6th-005.pdf>
- IUCN (2018) IUCN Red List of Ecosystems. Accessed in August 2021 [https://iucnrle.org/resources/published-assessments/Jackson, M.V. & Straw, P. \(eds\) \(2021\) Coastal hightide shorebird habitat management guidelines. figshare. Online resource. doi: 10.6084/m9.figshare.16628560.v1](https://iucnrle.org/resources/published-assessments/Jackson, M.V. & Straw, P. (eds) (2021) Coastal hightide shorebird habitat management guidelines. figshare. Online resource. doi: 10.6084/m9.figshare.16628560.v1)
- IUCN (2019) IUCN Technical Evaluation – Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai-Gulf of China (Phase I). <https://whc.unesco.org/document/176195>
- IUCN (2021) IUCN Technical Evaluation – Getbol, Korean Tidal Flat (Republic of Korea) <https://whc.unesco.org/document/176195>
- Jackson, M.V., Chio, C.Y., Amano, T., Estrella, S.M., Lei, W., Moores, N., Mundkur, T., Rogers, D.I. & Fuller, R.A. (2020). Navigating coasts of concrete: pervasive use of artificial habitats by shorebirds in the Asia-Pacific. *Biol. Conserv.* 247, 108591.
- Jackson, Micha V; Straw, Phill (eds) 2021: Coastal hightide shorebird habitat management guidelines. figshare. Online resource. doi: 10.6084/m9.figshare.16628560.v1
- Jiangsu Marine and Fisheries Bureau. 2016. Marine Ecological Red Line Protection Plan of Jiangsu Province (2016-2020) (in chinese)
- Jin, H.K. & Yoon, I.J. (2021) A review of the ocean economy of North Korea: Relationship between economic status and fisheries policy. In: Lee, J.L.; Suh, K.-S.; Lee, B.; Shin, S., & Lee, J. (eds.), *Crisis and Integrated Management for Coastal and Marine Safety. Journal of Coastal Research, Special Issue No. 114*: 340–344. DOI: 10.2112/JCR-SI114-069.1

- Keith, D.A., Altieri, A.H., Loidi, J. & Bishop, M.J. (2020) MFT1.3 Coastal saltmarshes and reedbeds. In: Keith, D.A., Ferrer-Paris, J.R., Nicholson, E. & Kingsford, R.T. (eds.). *The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups*. IUCN, Gland, Switzerland. DOI:10.2305/IUCN.CH.2020.13.en.
- Kim, H-B. (2021a) Bird droppings may twist Korea's vision for becoming 'solar hub'. August 10 2021. KOPICO. <https://kopico.or.kr/birds-droppings-may-twist-koreas-vision-for-becoming-solar-hub/>
- Kim, I.G., Kim, Y.B., Kim, R.H. & Hyon, T.S. (2021) Spatial distribution, origin and contamination assessment of heavy metals in surface sediments from Jangsong tidal flat, Kangryong river estuary, DPR Korea. *Marine Pollution Bulletin* 168: 112414. <https://doi.org/10.1016/j.marpolbul.2021.112414>
- Kim, J., Kim, I-H., Kim, M-S., Lee, H.R., Kim, Y.J., Park, S., & Yang, D. (2021b) Occurrence and diet analysis of sea turtles in Korean shore. *Journal of Ecology and Environment* 45:23. <https://doi.org/10.1186/s41610-021-00206-w>
- Kim, J.Y., & Han, I.S. (2017) Sea surface temperature time lag due to the extreme heat wave of August 2016. *Journal of the Korean Society of Marine Environment & Safety* 23: 677-683. <https://doi.org/10.7837/kosomes.2017.23.6.677>
- Kirezci, E., Young, I.R. Ranasinghe, R., Muis, S., Nicholls, R.J., Lincke, D. & Hinkel, J. (2020) Projections of global-scale extreme sea levels and resulting episodic coastal flooding over the 21st Century. *Scientific Reports* 10(1): 11629. DOI: 10.1038/s41598-020-67736-6
- KMA (2019) Abnormal climate report 2018, Korea Meteorological Administration, pp. 1-200.
- Koh, C.H. & Khim, J.S. (2014) The Korean tidal flat of the Yellow Sea: Physical setting, ecosystem and management. *Ocean and Coastal Management* 102: 398-414. <https://doi.org/10.1016/j.ocecoaman.2014.07.008>
- Ko, Y.K. & Schubert, D.K. (2011) South Korea's plans for tidal power: When a "Green" solution creates more problems. NAPSNet Special Reports, <https://nautilus.org/napsnet/napsnet-special-reports/south-koreas-plans-for-tidal-power-when-a-green-solution-creates-more-problems/>
- Kuang, F.L., Coleman, J.T., Hassell, C.J., Leung, K.S.K., Maglio, G., Ke, W.J., Cheng, C.Y., Zhao, J.Y., Zhang, Z.W., & Ma, Z.J. (2021) Seasonal and population differences in migration of Whimbrels in the East Asian-Australasian Flyway. *Avian Research* 11:24. <https://doi.org/10.1186/s40657-020-00210-z>
- Kulp, S. A. & Strauss, B.H. (2019) New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nature Communications* 10: 4844. <https://doi.org/10.1038/s41467-019-12808-z>
- Lee, G.-K. (2010) The status of seabirds on Sasu and Chilbal islands, and the management of invasive species. Pp. 134-137 in Birds Korea, *The Birds Korea Blueprint for the*

*conservation of Avian Biodiversity in the South Korean part of the Yellow Sea.* Birds Korea.

- Lee, H.-Y., Jeong, Y.-H., Kim, D.-H., Kim, D.-S., Cho, W.-H. & Hong, S.-J. (2020) Effects of large-scale coastal construction on storm surge height in shallow coastal zones of the Yellow Sea, South Korea. *Journal of Coastal Research* 95(SI): 252-256. DOI: 10.2112/SI95-049.1
- Lee, Y.G., Kim, S., Lee, H.W. & Mee, M.B. (2008) Chemical properties of sediment and increase of reed (*Phragmites australis*) stands at Suncheon Bay. *Journal of Korean Wetlands Society*10(3): 9-26.
- Lei, G.C., Zhang, Z.W., Yu, X.B., Zhang, M.X. (2017) *China coastal wetland conservation management strategy.* Higher Education Press, Beijing. [in Chinese]
- Liang, C. & Pauly, D. (2020) Masking and unmasking fishing down effects: The Bohai Sea (China) as a case study. *Ocean & Coastal Management* 184 (2020) 105033. DOI: 10.1016/j.ocecoaman.2019.105033
- Liang, X.X., Tian, C.G., Zong, Z., Wang, X.P., Jiang, W.Y.H., Chen, Y.J., Ma, J.M., Luo, Y.M., Li, J. & Zhang, G. (2018) Flux and source-sink relationship of heavy metals and arsenic in the Bohai Sea, China. *Environmental Pollution* 242(Pt B): 1353-1361. DOI: 10.1016/j.envpol.2018.08.011
- Liang, Y.B. & Wang, B. (2001) Alien marine species and their impacts in China. *Biodiversity Science* 9: 458–465. DOI: 10.17520/biods.2001066 [in Chinese]
- Li, B., Yuan, X., Chen, M., Bo, S.Q., Guo, Y., Zhao, S.S., Ma, Z.J. & Wang, T.H. (2020) How to strive for balance of coastal wind energy development with waterbird conservation in the important coastal wetlands, a case study in the Chongming Islands of East China. *Journal of Cleaner Production* 263: 121547. <https://doi.org/10.1016/j.jclepro.2020.121547>
- Li, F., Xu, M., Wang, Z. & Xu, W. (2014) Ecological restoration zoning for a marine protected area: a case study of Haizhouwan National Marine Park, China. *Ocean and Coastal Management* 98: 158-166. <https://doi.org/10.1016/j.ocecoaman.2014.06.013>
- Li, H., Jiang, W., Pan, Y., Li, F., Wang, C., & Tian, H. (2021) Occurrence and partition of organochlorine pesticides (OCPs) in water, sediment, and organisms from the eastern sea area of Shandong Peninsula, Yellow Sea, China. *Marine Pollution Bulletin* 162: 111906. <https://doi.org/10.1016/j.marpolbul.2020.111906>
- Li, J., Dong, H., Zhang, D., Han, B., Zhu, C., Liu, S., Liu, X., Maa, Q., & Li, X. (2015) Sources and ecological risk assessment of PAHs in surface sediments from Bohai Sea and northern part of the Yellow Sea, China. *Marine Pollution Bulletin* 96: 485–490. <https://doi.org/10.1016/j.marpolbul.2015.05.002>
- Li, P., Pan, Y., Fang, Y., Du, M., Pei, F., Shen, F., Xu, B. & Hu, Q. (2019) Concentrations and health risks of inorganic arsenic and methylmercury in shellfish from typical

- coastal cities in China: a simultaneous analytical method study. *Food Chemistry* 278: 587-592. <https://doi.org/10.1016/j.foodchem.2018.11.085>
- Li, Q., & Sun, X. (2020) Progress on microplastics research in the Yellow Sea, China. *Anthropocene Coasts* 3: 43-52. <https://doi.org/10.1139/anc-2018-0033>
- Li, Y.R., Ma, S.Y., Fu, C.H., Tian, Y.J., Li, J.C., Sun, P., Ye, Z.J. & Liu, Y. (2021) Appraising the status of fish community structure in the Yellow Sea based on an indicator-testing framework. *Frontiers in Marine Science* 8: 646733. <https://doi.org/10.3389/fmars.2021.646733>
- Lin, C., Ning, X., Su, J., Lin, Y., & Xu, B. (2005) Environmental changes and the responses of the ecosystems of the Yellow Sea during 1976-2000. *Journal of Marine Systems* 55: 223-234. doi:10.1016/j.jmarsys.2004.08.001
- Lin, X.Z., Wang, N.F., Chen, K.S. & Zhao, A.Y. (2005) Alien marine species and their ecological impacts in China. *Advances in Marine Science* 23(Suppl. 1): 110–116. [in Chinese]
- Lin, Y.P., Gao, Z.X. & Zhan, A.B. (2015) Introduction and use of non-native species for aquaculture in China: status, risks and management solutions. *Reviews in Aquaculture* 7: 28–58. doi: 10.1111/raq.12052
- Liu, B.L., Wu, H.T., Zhang, Z.K., Wei, G.E., Wang, Y., Zheng, J., Ji, X.P. & Jiang, S.N. (2021) Recent evolution of the intertidal sand ridge lines of the Dongsha Shoal in the modern radial sand ridges, East China. *International Journal of Environmental Research and Public Health* 18:1573. doi: 10.3390/ijerph18041573
- Liu, D.Y., Keesing, J.K. & He, P.M., Wang, Z.L., Shi, Y.J. & Wang, Y.J. (2013) The world's largest macroalgal bloom in the Yellow Sea, China: formation and implications. *Estuarine, Coastal and Shelf Science* 129: 2–10. <https://doi.org/10.1016/j.ecss.2013.05.021>
- Liu, S.H., Liu, Y., Alabia, I.D., Tian, Y.J., Ye, Z.J., Yu, H.Q., Li, J.C. & Cheng, J.H. (2020) Impact of climate change on wintering ground of Japanese Anchovy (*Engraulis japonicus*) using marine geospatial statistics. *Frontiers in Marine Science* 7:604. doi:10.3389/fmars.2020.00604
- Liu, X., Meng, R. L., Xing, Q. G., Lou, M. J., Chao, H. & Bing, L. (2015). Assessing oil spill risk in the Chinese Bohai Sea: a case study for both ship and platform related oil spills. *Ocean and Coastal Management* 108,140–146. doi:10.1016/j.ocecoaman.2014.08.01
- Liu, Y., Li, M.C., Zhou, M.X., Yang, K. & Mao, L. (2013) Quantitative analysis of the waterline method for topographical mapping of tidal flats: A case study in the Dongsha Sandbank, China. *Remote Sensing* 5: 6138-6158. doi:10.3390/rs5116138
- Liu, Y.X., Li, M.C., Cheng, L., Li, F.X. & Chen, K.F. (2012) Topographic mapping of offshore sandbank tidal flats using the waterline detection method: A case study on the

- Dongsha Sandbank of Jiangsu radial tidal sand ridges, China. *Marine Geodesy* 35: 362-378. DOI: 10.1080/01490419.2012.699501
- Long, A., Poole, C., Eldridge, M., Won, P.-O., & Lee, K.-S. (1988) *A survey of coastal wetlands and shorebirds in South Korea, Spring 1988*. Asian Wetland Bureau, Kuala Lumpur.
- LT&C (2018) Yellow Sea: China will halt land reclamation along its coast. [<https://www.ltandc.org/yellow-sea-china-will-halt-land-reclamation-along-its-coast/>] (Accessed: June 12 2022)
- Luan, H.L., Ding, P.X., Wang, Z.B., Ge, J.Z. & Yang, S.L. (2016) Decadal morphological evolution of the Yangtze Estuary in response to river input changes and estuarine engineering projects. *Geomorphology* 265: 12-23. <https://doi.org/10.1016/j.geomorph.2016.04.022>
- Luan, X.W., Ran, W.M., Wang, K., Wei, X.Y., Shi, Y.F. & Zhang, H. (2019) New interpretation for the main sediment source of the rapidly deposited sediment drifts on the northern slope of the South China Sea. *Journal of Asian Earth Sciences* 171:118-133. <https://doi.org/10.1016/j.jseaes.2018.11.004>
- Luo, X.X., Yang, S.L., Zhang, J. (2012) The impact of the Three Gorges Dam on the downstream distribution and texture of sediments along the middle and lower Yangtze River (Changjiang) and its estuary, and subsequent sediment dispersal in the East China Sea. *Geomorphology* 179: 126-140. <https://doi.org/10.1016/j.geomorph.2012.05.034>
- MacKinnon J., Verkuil Y. I. & Murray N. J. (2012) IUCN Situation Analysis on East and Southeast Asian intertidal habitats, with particular reference to the Yellow Sea (including the Bohai Sea). *Occasional Paper of the IUCN Species Survival Commission No. 47*. IUCN, Gland, Switzerland and Cambridge.
- Makowsy, P., Town, J., Kae, M.Y., & Pitz, S.J. (2021) North Korea's tideland reclamation efforts. 38 North. Stimson Centre. <https://www.38north.org/2021/12/north-koreas-tideland-reclamation-efforts/>
- Ma, M., Feng, Z., Guan, C., Ma, Y., Xu, H. & Li, H. (2001) DDT, PAH and PCB in sediments from the intertidal zone of the Bohai Sea and the Yellow Sea. *Marine Pollution Bulletin* 42: 132–136. [https://doi.org/10.1016/S0025-326X\(00\)00118-1](https://doi.org/10.1016/S0025-326X(00)00118-1)
- Ma, S., Cheng, J., Li, J., Liu, Y., Wan, R. & Tian, Y. (2018). Interannual to decadal variability in the catches of small pelagic fishes from China Seas and its responses to climatic regime shifts. *Deep Sea Res. Part II* 159, 112–129. doi: 10.1016/j.dsr2.2018.10.005
- Ma, S.Y., Liu, Y., Li, J.C., Fu, C.H., Ye, Z.J., Sun, P., Yu, H.Q., Cheng, J.H. & Tian, Y.J. (2019a) Climate-induced long-term variations in ecosystem structure and atmosphere-ocean-ecosystem 29 processes in the Yellow Sea and East China Sea. *Progress in Oceanography* 175: 183-197. doi:10.1016/j.pocean.2019.04.008

- Ma, S., Cheng, J., Li, J., Liu, Y., Wan, R. & Tian, Y. (2019b). Interannual to decadal variability in the catches of small pelagic fishes from China Seas and its responses to climatic regime shifts. *Deep Sea Res. Part II* 159, 112–129. doi: 10.1016/j.dsr2.2018.10.005
- Ma, Z.J., Chen, Y., Melville, D.S., Fan, J., Liu, J.G., Dong, J.W., Tan, K., Cheng, X.F., Fuller, R.A., Xiao, X.M. & Li, B. (2019c) Changes in area and number of nature reserves in China. *Conservation Biology* 33: 1066-1075. DOI: 10.1111/cobi.13285
- Ma, Z.J., Melville, D.S., Liu, J.G., Chen, Y., Yang, H.Y., Ren, W.W., Zhang, Z.W., Piersma, T., & Li, B. (2014) Rethinking China's new great wall. *Science Vol 346, Issue 6212*: 912-914. Doi: 10.1126/science.1257258
- Ma, Z.J., Wang, Y., Gan, X.J., Li, B., Cai, Y.T & Chen, J.K. (2009) Waterbird population changes in the wetlands at Chongming Dongtan in the Yangtze River Estuary, China. *Environmental Management* 43: 1187-1200. DOI 10.1007/s00267-008-9247-7
- McCarthy, C., Banfill, J., & Hoshino, B. (2021) National parks, protected areas and biodiversity conservation in North Korea: opportunities for international collaboration. *Journal of Asia-Pacific Biodiversity* 14: 290-298. <https://doi.org/10.1016/j.japb.2021.05.006>
- McCloskey, S.E., Uher-Koch, B.D., Schmutz, J.A. & Fondell, T.F. 2018. International migration patterns of Red-throated Loons *Gavia stellata* from four breeding populations in Alaska. *PLoS ONE* 131: e0189954. <https://doi.org/10.1371/journal.pone.0189954>.
- Melville, D.S. & Shortridge, K.F. (2006) Migratory waterbirds and avian influenza in East Asia. Pp. 432-438 in Boere, G.C., Galbraith, C.A. & Stroud, D.A. (Eds.). *Waterbirds Around the World*. The Stationery Office, Edinburgh.
- Melville, D.S. (2015) Tianjin's tragic explosions highlight risks to the coastal environment from China's expanding chemical industries. *Wader Study* 122: 85-86.
- Melville, D.S., Chen, Y. & Ma, Z.J. (2016) Shorebirds along the Yellow Sea coast of China face an uncertain future – a review of threats. *Emu* 116: 100-110. <http://dx.doi.org/10.1071/MU15045>
- Melville, D.S. (2019) China's coasts – a time for cautious optimism? *Wader Study* 125: 1-3. doi:10.18194/ws.00103
- Meng, L.Y., Song, B.Y., Zhong, H.F., Ma, X.D., Wang, Y.J., Ma, D.H., Lu, Y., Gao W., Wang, Y.W. & Jiang, G.B. (2021) Legacy and emerging per- and polyfluoroalkyl substances (PFAS) in the Bohai Sea and its inflow rivers. *Environment International* 156: 106735. <https://doi.org/10.1016/j.envint.2021.106735>
- Ministry of Environment, Republic of Korea. 1999-2020. Annual Reports of the Winter Bird Census [in Korean].
- Ministry of Ocean and Fisheries 2000-2020 Survey Reports.



- Ministry of Natural Resources (PRC) (2021) Outline of the Plan for Ecological Protection and High-Quality Development in the Yellow River Basin.  
<https://mp.weixin.qq.com/s/XKpwEHnUtMhv7OKxNJ6SmA>
- MOA 2017. [http://www.moa.gov.cn/nybgb/2017/dyiq/201712/t20171227\\_6130333.htm](http://www.moa.gov.cn/nybgb/2017/dyiq/201712/t20171227_6130333.htm)
- MoLEP 2018. Ministry of Land and Environment Protection. DPRK.
- Moores N., Kim S-K, Park S-B & T. Sadayoshi (Eds). (2001) *Yellow Sea Ecoregion: Reconnaissance Report on Identification of Important Wetland and Marine Areas for Biodiversity. Volume 2: South Korea*. WBK and WWF-Japan, Busan. 142 pp (Korean and English versions).
- Moores, N. (2012) The distribution, abundance and conservation of avian biodiversity in Yellow Sea habitats in the Republic of Korea. University of Newcastle Research Higher Degree Thesis.
- Moores, N., Rogers, D. I., Rogers, K. & Hansbro, P.M. (2016) Reclamation of tidal flats and shorebird declines in Saemangeum and elsewhere in the Republic of Korea. *Emu* 116: 136-146. <http://dx.doi.org/10.1071/MU16006>
- Moores, N. (2018) Saemangeum estuarine system (Republic of Korea): Before and after reclamation. Pp. 405-412 In: Finlayson C., Milton G., Prentice R., Davidson N. (eds) *The Wetland Book*. Springer, Dordrecht. [https://doi.org/10.1007/978-94-007-4001-3\\_36](https://doi.org/10.1007/978-94-007-4001-3_36)
- Moores, N. (2021) An Introduction to the International Importance of Asan Bay to Waterbirds. Birds Korea, August 31<sup>st</sup> 2021. <http://www.birdskoreablog.org/?p=25156>
- Moores, N. & Park M-N. (2021a) Survey of Far Eastern Curlew *Numenius madagascariensis*: July 21st-25th 2021. [https://www.eaaflyway.net/wp-content/uploads/2021/10/2021알락꼬리마도요-조사-보고서\\_Eng.pdf](https://www.eaaflyway.net/wp-content/uploads/2021/10/2021알락꼬리마도요-조사-보고서_Eng.pdf)
- Moores, N. & Park M. (2021b) *International Importance of the Hwaseong Wetlands Flyway Network Site: 2021 Report*. A Report on the Hwaseong Wetlands Project (2020-2021) prepared by Birds Korea as part of the EAAFP-Hwaseong City Project, Collaboration for the Conservation of Hwaseong Wetlands.
- Muller, J.R.M., Chan, Y.-C., Piersma, T., Chen, Y.-P., Aarninkhof, S.G.J., Hassell, C.J., Tao, J.-F., Gong, Z., Wang, Z.B. & van Maren, D.S. (2020a) Building for nature: Preserving threatened bird habitat in port design. *Water* 12: 2134. <https://doi.org/10.3390/w12082134>
- Muller, J.R.M., Chen, Y.P., Aarninkhof, S.G.J., Chan, Y.C., Piersma, T., van Maren, D.S., Tao, J.F., Wang, Z.B., Gong, Z. (2020b) Ecological impact of land reclamation on Jiangsu coast (China): a novel ecotope assessment for Tongzhou Bay. *Water Science and Engineering* 13: 57-64. <https://doi.org/10.1016/j.wse.2020.04.001>
- Mundkur, T. & Langendoen, T. (2022) *Report on the Conservation Status of Migratory Waterbirds of the East Asian – Australasian Flyway Partnership*. First Edition. Report

to the East Asian – Australasian Flyway Partnership. Wetlands International, Ede, The Netherlands.

- Murray, N.J., Clemens, R.S., Phinn, S.R., Possingham, H.P. & Fuller, R.A. (2014) Tracking the rapid loss of tidal wetlands in the Yellow Sea. *Frontiers in Ecology and the Environment* 12: 267–272, doi:10.1890/130260
- Murray, N.J., Ma, Z.J., & Fuller, R.A. (2015) Tidal flats of the Yellow Sea : A review of ecosystem status and anthropogenic threats. *Austral Ecology* 40: 472–481. doi:10.1111/aec.12211
- Murray, N. J., Marra, P. P., Fuller, R. A., Clemens, R. S., Dhanjal-Adams, K., Gosbell, K. B., Hassell, C.J., Iwamura, T., Melville, D., Minton, C.D.T., Riegen, A.C., Rogers, D.I., Woehler, E.J. & Studds, C. E. (2017) The large-scale drivers of population declines in a long-distance migratory shorebird *Ecography* 41: 867-876. doi:10.1111/ecog.2957
- Murray, N. J., Phinn, S. R., DeWitt, M., Ferrari, R., Johnston, R., Lyons, M. B., Clinton, N., Thau, D. & Fuller, R. A. (2019) The global distribution and trajectory of tidal flats. *Nature* 565:222-225. <http://dx.doi.org/10.1038/s41586-018-0805-8>
- Murray, N.J., Worthington, T.A., Bunting, P., Duce, S., Hagger, V., Lovelock, C.E., Lucas, R., Saunders, M.I., Sheaves, M., Spalding, M., Waltham, N.J. & Lyons, M.B. (2022). High-resolution mapping of losses and gains of Earth's tidal wetlands. *Science*. DOI: <https://doi.org/10.1126/science.abm9583>
- Muzaffar, S.B., Takekawa, J.Y., Prosser, D.J., Newman, S.H., Xiao, X.M. (2010) Rice production systems and avian influenza: interactions between mixed-farming systems, poultry and wild birds. *Waterbirds* 33 (sp 1): 219-230.
- Nam, J. 2017, Legal and Institutional Mechanism for Marine Environmental Management of ROK, '2017 Capacity Building on Sustainable Management of Coastal and Marine Environment', Suncheon Bay Int'l Wetland Center, Suncheon, Korea.
- National Institute of Biological Resources (2009-2016) *Survey Reports of waterbirds or endemic species of Korea*.
- NEAMPAN North-East Asian Marine Protected Areas Network (NEAMPAN). (2021) *Marine Protected Areas in the Democratic People's Republic of Korea* (2022).
- Nicholls, R. J., Cazenave, A. (2010) Sea-Level Rise and Its Impact on Coastal Zones. *Science*, 328 (5985). 1517-1520 doi:10.1126/science.1185782
- NS Energy. (Undated) <https://www.nsenergybusiness.com/projects/jiangsu-rudong-h6-h10-offshore-wind-power-project>
- OECD. (2021) Fisheries and Aquaculture in Korea. [https://www.oecd.org/agriculture/topics/fisheries-and-aquaculture/documents/report\\_cn\\_fish\\_kor.pdf](https://www.oecd.org/agriculture/topics/fisheries-and-aquaculture/documents/report_cn_fish_kor.pdf)
- Park, J.W. (2019) Efforts to increase local communities' awareness of the importance of protecting the Spotted Seals that live on Baengneyongdo Island. Paper presented at YSLME MPA networking workshop. 14-16 January, Dalian, Liaoning, PR China

- Park, Y.K. (2020) The role of fishing disputes in China–South Korea relations. <https://www.nbr.org/publication/the-role-of-fishing-disputes-in-china-south-korea-relations/>
- Peng, H.B., Anderson, G.Q.A., Chang, Q., Choi, C.Y., Chowdhury, S.U., Clark, N.A., Gan, X.J., Hearn, R.D., Li, J., Lappo, E.G., Liu, W.L., Ma, Z.J., Melville, D.S., Phillips, J.F., Syroechkovskiy, E.E., Tong, M.X., Wang, S.L., Zhang, L. & Zöckler, C. (2017) The intertidal wetlands of southern Jiangsu Province, China – globally important for Spoon-billed Sandpipers and other threatened waterbirds, but facing multiple serious threats. *Bird Conservation International* 27: 305-322. doi:10.1017/S0959270917000223
- Peng, H-B., Chan, Y-C., Compton, T.I., Cheng, X-F., Melville, D.S., Zhang, S-D., Zhang, Z., Lei, G., Ma, Z., & Piersma, T. (2021) Mollusc aquaculture homogenizes intertidal soft-sediment communities along the 18,400 km long coastline of China. *Diversity and Distributions* 27: 1553-1567. <https://doi.org/10.1111/ddi.13302>
- Peng, H.B., Shi, J.B., Gan, X.J., Zhang, J., Ma, C., Piersma, T. & Melville, D.S. (2022) Efficient removal of *Spartina alterniflora* with low negative environmental impacts using imazapyr. *Frontiers in Marine Science* 9: 1054402. doi:10.389/fmars.2022.1054402
- Piersma, T., Lok, T., Chen, Y., Hassell, C.J., Yang, H.Y., Boyle, A., Slaymaker, M., Chan, Y.C., Melville, D.S., Zhang, Z.W. & Ma, Z.J. (2016) Simultaneous declines in survival of three shorebird species signals a flyway at risk. *Journal of Applied Ecology* 53: 479-490. doi: 10.1111/1365-2664.12582
- Prosser, D.J., Hungerford, L.L., Erwin, R.M., Ottinger, M.A., Takekawa, J.Y. & Ellis, E.C. (2013) Mapping avian influenza transmission risk at the interface of domestic poultry and wild birds. *Frontiers in Public Health* 1: 28. Doi: 10.3389/fpubh.2013.00028
- Purnell, C., Crosby, M. & Moon Y.M. (2017) *Conserving Shorebirds of the Geum Estuary: Year 1 Annual Report*. BirdLife report to Woodside Energy, BirdLife Australia. <https://static1.squarespace.com/static/5808a464579fb31efea202a8/t/5c0dfc594d7a9c6ed4382a4f/1544420490654/BirdLife+Geum+Estuary+Project-+year+1+report.pdf>
- Qi, L., Hu, C., Wang, M., Shang, S. & Wilson, C. 2017. Floating algae blooms in the East China Sea. *Geophys. Res. Lett.*, 44, 11501–11509
- Qu, L.Y., Zhan, J.X., & Sun, X.Q. (1999) Epidemiological and histopathological study on the Lymphocystis disease of cultured left-eyed flounder *Paralichthys olivaceus*. *Journal of Oceanography of Huanghai & Bohai Seas* 17: 43–47. [in Chinese]
- Ren, C., Wang, Z.M., Zhang, Y.Z., Zhang, B., Chen, L., Xi, Y.B., Xiao, X.M., Doughty, R.B., Liu, M.Y., Jia, M.M., Mao, D.H. & Song, K.S. (2019) Rapid expansion of coastal aquaculture ponds in China from Landsat observations during 1984–2016. *International Journal of Applied Earth Observation and Geoinformation* 82: 101902. 10.1016/j.jag.2019.101902

- Ren, J.L., Chen, J.S., Xu, C.L., van de Koppel, J., Thomsen, M.S., Qiu, S.Y., Cheng, F.Y., Song, W.J., Liu, Q.X., Xu, C., Bai, J.H., Zhang, Y.H., Cui, B.S., Bertness, M.D., Silliman, B.R., Li, B. & He, Q. (2021) An invasive species erodes the performance of coastal wetland protected areas. *Science Advances* 7: eabi8943
- Ren, M.E. & Shi, Y.L. (1986) Sediment discharge of the Yellow River (China) and its effect on the sedimentation of the Bohai and the Yellow Sea. *Continental Shelf Research* 6: 785-810. doi.org/10.1016/0278-4343(86)90037-3
- Reynolds, S., Aldridge, D., Christie, A., Choi, C.-Y., Jackson, M.V., Ju, R.-T., Leung, K.K.-S., Li, B., Lowe, R., Martin, P., Melville, D.S., Mundkur, T., Petrovan, S.O., Smith, R.K., Wang, S., White, T., Willott, K. & Sutherland, W.J. (2023) *Spartina* invasive management - a review of the evidence. OSF. <https://doi.org/10.17605/OSF.IO/3BWZX>
- Riegen, A.C., Vaughan, G.R. & Rogers, K.G. (2014) *Yalu Jiang estuary shorebird survey report 1999-2010*. Yalu Jiang Estuary National Nature Reserve, China and Miranda Naturalists' Trust, New Zealand.
- Riegen, A., Melville, D., Woodley, K., Ju S-I, Kim S-H., Pak S-I. & Pak U. (2016a) Shorebird survey of the Onchon County Coast of the Democratic People's Republic of Korea May 2015. *Stilt* 68: 40-45.
- Riegen, A., Melville, D., Woodley, K., Postill, B., Ju S-I, Hong H-S., Kim S-H. & Pak U. (2016b) Coastal shorebird survey in the provinces of North and South Pongyan, the Democratic People's Republic of Korea, April 2016. *Stilt* 69-70: 37:43.
- Riegen, A., Melville, D.S., Hare, W., Milius, N., Ko, H.C., Ju, S.I., Hong, H.S., Kim, S.H. & Ri, C.S. (2018a) Coastal shorebird survey in the province of North Pyongan, Democratic People's Republic of Korea, April 2017. *Stilt* 72: 15-20.
- Riegen, A., Melville, D.S., Woodley, K., Ri, S.I., Ju, S.I., Ri, C.J., Ji, H.K. & Ri, C.S. (2018b) Coastal shorebird survey in the province of North Pyongan, Democratic People's Republic of Korea, April 2018. *Stilt* 72: 21-26.
- Riegen, A., Melville, D.S., Woodley, K., Perry, W., Kwak, I.C., Ri, S.I., Hong, H.S., Ju, S.I. & Kim, J.H. (2020) Coastal shorebird surveys in the Provinces of South Hwanghae and North Pyongan, Democratic People's Republic of Korea, May 2019. *Stilt* 73-74: 75-79.
- Rogers, D.I., Piersma, T. & Hassell, C.J. (2006) Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation* 133: 225-235. <https://doi.org/10.1016/j.biocon.2006.06.007>
- Schmutz, J.A, Trust, K.A. & A.C. Matz. Red-throated loons (*Gavia stellata*) breeding in Alaska, USA, are exposed to PCBs while on their Asian wintering grounds. *Environ Poll.* 2009;157(8-9):2386-2393.

- Schuerch, M., Spencer, T., Temmerman, S., Kirwan, M.L., Wolff, C., Lincke, D., McOwen, C.J., Pickering, M.D., Reef, R., Vafeidis, A.T., Hinkel, J., Nicholls, R.J. & Brown, S. (2018) Future response of global coastal wetlands to sea-level rise. *Nature* 561(7722): 231-234. <https://doi.org/10.1038/s41586-018-0476-5>
- Seto, K. C., Güneralp, B. & Hutyra, L.R. (2012) Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences* 109(40): 16083-16088. [www.pnas.org/cgi/doi/10.1073/pnas.1211658109](http://www.pnas.org/cgi/doi/10.1073/pnas.1211658109)
- Shengli Oil Field Fact Sheet. Carbon Capture and Sequestration Technologies Programme, MIT. [<https://sequestration.mit.edu/tools/projects/shengli.html>]
- Si, Y., Xu, F., Wei, J., Zhang, L., Murray, N., Yang, R., Ma, K.P. & Gong, P. (2021). A systematic network-based migratory bird monitoring and protection system is needed in China. *Science Bulletin* 66 (10): 955-957. <https://doi.org/10.1016/j.scib.2021.01.033>
- Small, C. & R. Nicholls (2003). A Global Analysis of Human Settlement in Coastal Zones. *Journal of Coastal Research*. 19. 10.2307/4299200.
- SOAC. State Oceanic Administration, People's Republic of China. 2000-2015 Reports.
- Song, J. & L. Duan (2019) Chapter 17: The Bohai Sea. In: *World Seas: an Environmental Evaluation*. Vol. 2. Pp. 377-394.
- Song S-K., Lee S-W., Lee Y-K., Lee S-Y., Chang H-K., Choi S-S., Shin H-C., Park J-Y., Lee J-H. & Kim W-Y. (2017) First report and breeding record of the Chinese Crested Tern *Thalasseus bernsteini* on the Korean Peninsula. *Journal of Asia-Pacific Biodiversity* 10: 250-253. DOI: 10.1016/j.japb.2017.04.005
- Son, K., Kim, Y.K., Woo, C., Wang, S-J., Kim, Y., Oem, J-K., Jheong, W. & Jeong, J. (2018) Minimizing an outbreak of avian botulism (*Clostridium botulinum* type C) in Incheon, South Korea. *Journal of Veterinary Medical Science* 80: 553–556. doi: 10.1292/jvms.17-0519
- Son S-J., Lee K-S., Kwon I-K., Kang J-H., Lee S-K., Kim I-K., Cho H-J. & Yoo J-C. (2021) Black-Faced Spoonbill *Platalea minor* population trends, breeding success, and nest characteristics in the Chilsan Archipelago, South Korea. *Ornithological Science* 20: 57-64.
- Spalding, M. D., S. Ruffo, C. Lacambra, I. Meliane, L. Z. Hale, C. C. Shepard & M. W. Beck (2014) The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. *Ocean & Coastal Management* 90: 50-57. <https://doi.org/10.1016/j.ocecoaman.2013.09.007>
- Statistics Korea. *Statistics on the population of fishery households in Jellabok Province*, Census of Agriculture, Forestry and Fisheries.

- Studds, C. E., Kendall, B.E., Murray, N.J., Wilson, H.B., Rogers, D.I., Clemens, R.S., Gosbell, K., Hassell, C.J., Jessop, R., Melville, D.S., Milton, D.A., Minton, C.D.T., Possingham, H.P., Riegen, A.S., Straw, P., Woehler, E.J. & Fuller, R.A. (2017) Rapid population decline in migratory shorebirds relying on Yellow Sea tidal mudflats as stopover sites. *Nature Communications* 8: 14895 doi: 10.1038/ncomms14895.
- Syvitski, J. P. M., Kettner, A. J., Overeem, I., Hutton, E. W. H., Hannon, M. T., Brakenridge, G. R., Day, J., Vorosmarty, C., Saito, Y., Giosan, L. & Nicholls, R. J. (2009) Sinking deltas due to human activities. *Nature Geoscience* 2: 681-6.
- Syvitski, J., Ángel, J. R., Saito, Y., Overeem, I., Vörösmarty, C. J., Wang, H., & Olago, D. (2022) Earth's sediment cycle during the Anthropocene. *Nature Reviews Earth & Environment*. doi:10.1038/s43017-021-00253-w
- Tang, Q. (1989) Changes in the biomass of the Yellow Sea Ecosystem, In: K. Sherman & L.M. Alexander (Editors), Biomass Yields and Geography of Large Marine Ecosystems. III. Series; AAS Selected Symposium; 11 I. Westview Press, 493 pp.
- Tang, Q.S. (2009) Changing states of the Yellow Sea Large Marine Ecosystem: Anthropogenic Forcing and Climate Impacts. <https://www.cbd.int/ecosystems/doc/qisheng-tang-yslme-2009-en.pdf>
- Tang, Q.S., Ying, Y.P., & Wu, Q. (2016) The biomass yields and management challenges for the Yellow Sea Large Marine Ecosystem. *Environmental Development* 17 (Supplement 1): 175-181. <https://doi.org/10.1016/j.envdev.2015.06.012>
- Tang, Z.W., Huang, Q.F., Nie, Z.Q. & Yang, Y.F. (2015) Pollution threatens migratory shorebirds. *Science Vol 350 Issue 6265*: 1176-1177. <https://www.science.org/doi/10.1126/science.350.6265.1176-c>
- TEEB (2010) *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB* (The Economics of Ecosystem and Biodiversity). <https://portals.iucn.org/library/sites/library/files/documents/2010-051.pdf>
- Turner, S.J & J.E. Hewitt. (1997) Effects of Gallant for Spartina control. Conservation Advisory Science Notes No. 158, Department of Conservation, Wellington.
- UNDP (2014) Paving the way to a DDT-free China. <https://www.cn.undp.org/content/china/en/home/presscenter/articles/2014/10/pave-the-way-to-a-ddt-free-china.html>
- UNDP (2020) *Transboundary Diagnostic Analysis for the Yellow Sea Large Marine Ecosystem (2020)*. UNDP/GEF Yellow Sea Large Marine Ecosystem (YSLME) Phase II Project. Incheon, RO Korea. pp 75. <https://iwllearn.net/resolveuid/93fd90e6-8820-4d65-a370-4f484f34be10>
- UNDP/GEF (2007) UNDP/GEF Project: Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem. Transboundary Diagnostic Analysis. <https://iwllearn.net/resolveuid/3a99916c9fb6c58e9c386647ad6c4769>

- UNDP/GEF (2009) *UNDP/GEF Project: Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem. Strategic Action Programme*.  
<https://iwlearn.net/resolveuid/5379d116-f506-4953-b36e-65b5fca2283d>
- UNESCO. 2021. Operational Guidelines for the Implementation of the World Heritage Convention. <https://whc.unesco.org/document/190976>
- UNESCO/ICOMOS/ICCROM/IUCN. 2022. Guidance and Toolkit for Impact Assessments in a World Heritage Context. Paris, UNESCO. <https://whc.unesco.org/document/195279>
- Wang, A.M., Wang, H.J., Bi, N.S., & Wu, X. (2016) Sediment transport and dispersal pattern from the Bohai Sea to the Yellow Sea. *Journal of Coastal Research* 74 (Sp 1): 104–116. <https://doi.org/10.2112/SI74-010.1>
- Wang, G.G., Peng, J.L., Yang, D.D., Zhang, D.H., & Li, X.G. (2015) Current levels, composition profiles, source identification and potentially ecological risks of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in the surface sediments from Bohai Sea. *Marine Pollution Bulletin* 101: 834–844. <https://doi.org/10.1016/j.marpolbul.2015.11.028>
- Wang, G., Peng, J., Xu, X., Zhang, D., & Li, X. (2016) Polybrominated diphenyl ethers in sediments from the Southern Yellow Sea: Concentration, composition profile, source identification and mass inventory. *Chemosphere* 144: 2097–2105. <http://dx.doi.org/10.1016/j.chemosphere.2015.10.088>
- Wang H. J., Bi N. S., Saito Y. et al. (2010) Recent changes in sediment delivery by the Huanghe (Yellow River) to the sea: causes and environmental implications in its estuary. *J. Hydrol.* 391, 302–313.
- Wang, H., Wang, Q., Bowler, P.A., Xiong, W. (2016) Invasive aquatic plants in China. *Aquatic Invasions* 11: 1–9. <https://doi.org/10.3391/ai.2016.11.1.01>
- Wang, R.M., Tang, J.H., Xie, Z.Y., Mi, W.Y., Chen, Y.J., Wolschke, H., Tian, C.G., Pan, X.H., Luo, Y.M. & Ebinghaus, R. (2015) Occurrence and spatial distribution of organophosphate ester flame retardants and plasticizers in 40 rivers draining into the Bohai Sea, north China. *Environmental Pollution* 198: 172-178. <https://doi.org/10.1016/j.envpol.2014.12.037>
- Wang, R.M., Zhang, J., Yang, Y.Y., Chen, C.E., Zhang, D.C. & Tang, J.H. (2022) Emerging and legacy per- and polyfluoroalkyl substances in the rivers of a typical industrialised province of China: Spatiotemporal variations, mass discharges and ecological risks. *Frontiers in Environmental Science* 10:986719. doi: 10.3389/fenvs.2022.986719
- Wang, W., Liu, H., Li, Y.Q. & Su, J.L. (2014) Development and management of land reclamation in China. *Ocean & Coastal Management* 102 Part B: 415-425. <https://doi.org/10.1016/j.ocecoaman.2014.03.009>
- Wang, X.X., Xiao, X.M., Xu, X., Zou, Z.H., Chen, B.Q., Qin, Y.W., Zhang, X., Dong, J.W., Liu, D.Y., Pan, L.H. & Li, B. (2021) Rebound in China's coastal wetlands following

- conservation and restoration. *Nature Sustainability* 4: 1076-1083.  
<https://doi.org/10.1038/s41893-021-00793-5>.
- Ward, R., & Hong, D.U. 2021. Environmental Impact Assessment in North Korean Environmental Law: Origins, Evolution, and a Comparative Analysis. *Ecology Law Currents*. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3926707](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3926707)
- Wauchope, S.W., Jones, J.P.G., Geldmann, J., Simmons, B.I., Amano, T., Blanco, D.E., Fuller, R.A., Johnston, A., Langendoen, T., Mundkur, T., Nagy, S., & Sutherland, W.J. (2022) Protected areas have a mixed impact on waterbirds, but management helps. *Nature* doi.org/10.1038/s41586-022-04617-0
- Weller, D.W., Burdin, A.M., Würsig, B., Taylor, B.L. & Brownell, R.L. (2002) The western gray whale: a review of past exploitation, current status and potential threats. *Journal of Cetacean Research and Management* 4: 7–12. Retrieved 10 March 2016.
- Wille, M., Lisovski, S., Risely, A., Ferenczi, M., Roshier, D., Wong, F.Y.K., Breed, A.C., Klaassen, M. & Hurt, A.C. (2019) Serologic evidence of exposure to Highly Pathogenic Avian Influenza H5 viruses in migratory shorebirds, Australia. *Emerging Infectious Diseases* 25: 1903-1910. DOI: <https://doi.org/10.3201/eid2510.190699>
- Woo, H.T. (2020) Comparison of Protected Areas in South and North Korea Based on International Conservation Criteria. *Journal of the Environmental Sciences* 1:1-14.
- World Database on Protected Areas (WDPA). <https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA>
- Ministry of Housing and Urban-Rural Development, People's Republic of China, (2018) Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I). Nomination text. <https://whc.unesco.org/document/166293>
- Cultural Heritage Administration, Republic of Korea, (2019) Getbol, Korean Tidal Flat - For Inscription on the World Heritage List. Nomination text. <https://whc.unesco.org/document/172303>
- Wu, Q., Guan, L.S., Li, Z.Y., Shan, X.J. & Jin, X.S. (2019) Decadal variations in the community status of economically important invertebrates in the Bohai Sea. *Acta Oceanologica Sinica* 38: 60–66. <https://doi.org/10.1007/s13131-019-1488-1>
- WWF (2006a) *Fish of the Yellow Sea Ecoregion and their habitats*. Yellow Sea Ecoregion Planning Programme. [<https://www.wwf.or.jp/activities/data/200710y-seamap04e.pdf>] (Accessed 23 September 2022).
- WWF (2006b) *Mammals of the Yellow Sea Ecoregion and their habitats*. <https://www.wwf.or.jp/activities/data/200710y-seamap02e.pdf>
- WWF, KORDI & KEI (2008) *Biological assessment report of the Yellow Sea Ecoregion, Ecologically important areas for the Yellow Sea Ecoregion's biodiversity*. <http://www.wwf.or.jp/activities/lib/pdf/200710y-seamap01e.pdf> (02e-11e.pdf for different information sheets)



- Xiao, C.L., Jian, H.M., Chen, L.F., Liu, C., Gao, H.Y., Zhang, C.S., Liang, S.K., & Li, Y.B. (2017) Toxic metal pollution in the Yellow Sea and Bohai Sea, China: distribution, controlling factors and potential risk. *Marine Pollution Bulletin* 119: 381–389. <https://doi.org/10.1016/j.marpolbul.2017.03.027>
- Xiao, X., Agusti, S., Lin, F., Li, K., Pan, Y.R., Yu, Y., Zheng, Y.H., Wu, J.P. & Duarte, C.M. (2017) Nutrient removal from Chinese coastal waters by large-scale seaweed aquaculture. *Scientific Reports* 7: 46613. <https://doi.org/10.1038/srep46613>
- Xia, S. 1960. Fisheries of the Bohai Sea, Yellow Sea and East China Sea. Mar. fish. Res. Pap. 2: 73-94. In Chinese.
- Xia, S.X., Yu, X.B., Millington, S., Liu, Y., Jia, Y.F., Wang, L.Z., Hou, X.Y., & Jiang, L.G. (2017) Identifying priority sites and gaps for the conservation of migratory waterbirds in China's coastal wetlands. *Biological Conservation* 210, Part B: 72-82. <http://dx.doi.org/10.1016/j.biocon.2016.07.025>
- Xing, Qianguo & Guo, Ruihong & Wu, Lingling & An, Deyu & Cong, Ming & Qin, Song & Li, Xuerong. (2017). High-Resolution Satellite Observations of a New Hazard of Golden Tides Caused by Floating Sargassum in Winter in the Yellow Sea. *IEEE Geoscience and Remote Sensing Letters*. PP. 1-5. 10.1109/LGRS.2017.2737079.
- Xinhua. 2021. 'Baoying county of Jiangsu boosts green development by promoting solar and wind energy' The State Council The People's Republic of China. [[https://english.www.gov.cn/news/photos/202111/04/content\\_WS61833654c6d0df57f98e47f0.html](https://english.www.gov.cn/news/photos/202111/04/content_WS61833654c6d0df57f98e47f0.html)] (Accessed: 6 September 2022)
- Xiong, W., Shen, C.Y., Wu, Z.X., Lu, H.S. & Yan, Y.R. (2017) A brief overview of known introductions of non-native marine and coastal species into China. *Aquatic Invasions* 12: 109–115. DOI: <https://doi.org/10.3391/ai.2017.12.1.11>
- Xu, B. D. & Jin, X. S. (2005). Variations in fish community structure during winter in the southern Yellow Sea over the period 1985–2002. *Fish. Res.* 71, 79–91. doi: 10.1016/j.fishres.2004.07.011
- Xu, H.G., Ding, H., Li, M.Y., Qiang, S., Guo, J.Y., Han, Z.M., Huang, Z.G., Sun, H.Y., He, S.P., Wu, H.R., Wan, F.H. (2006) The distribution and economic losses of alien species invasion to China. *Biological Invasions* 8: 1495–1500. <https://doi.org/10.1007/s10530-005-5841-2>
- Xu, Y.H., Qian, Y., Chen, Y. & Shi, C. (2010) Effect of construction of offshore wind farm in intertidal zones on birds in Dongsha Sandbank. *Administration & Technique of Environmental Monitoring* 2: 19-23. [in Chinese]
- Yang, H. Y., Chen, B., Barter, M., Piersma, T., Zhou, C. F., Li, F. S. & Zhang, Z. W. (2011), Impacts of tidal land reclamation in Bohai Bay, China; ongoing losses of critical Yellow Sea waterbird staging and wintering sites, *Bird Conservation International*, v.21, p.241-259.

- Yang, H.Y., Chen, B., Piersma, T., Zhang, Z.W. & Ding, C.Q. (2016) Molluscs of an intertidal soft-sediment area in China: Does overfishing explain a high density but low diversity community that benefits staging shorebirds? *Journal of Sea Research* 109: 20-28. <https://doi.org/10.1016/j.seares.2016.01.006>
- Yang, J., Yan, F. & Chen, M. (2021) Effects of sea level rise on storm surges in the south Yellow Sea: A case study of Typhoon Muifa (2011). *Continental Shelf Research* 215: 104346. <https://doi.org/10.1016/j.csr.2021.104346>
- Yang, M., & Li, Z. (2017) Population genetic structure of the mantis shrimp *Oratosquilla oratoria* (Crustacea: Squillidae) in the Yellow Sea and East China Sea. *Chinese Journal of Oceanology and Limnology* 36(3):1-8. DOI: 10.1007/s00343-018-7030-z
- Yang S., Zhang J., Zhu J. et al. (2005) Impact of dams on Yangtze River sediment supply to the sea and delta intertidal wetland response. *J. Geophys. Res.* 110, F03006.
- Yang, Z., Li, J., Han, Y., Hassell, C.J., Leung, K-S.K., Melville, D.S., Yu, Y., Zhang, L. & Choi, C-Y. (2021) Coastal wetlands in Lianyungang, Jiangsu Province, China: probably the most important site globally for the Asian Dowitcher (*Limnodromus semipalmatus*). *Avian Research* 12: 38. <https://doi.org/10.1186/s40657-021-00272-7>
- Yang, Z.Y., Lagassé, B.J., Xiao, H., Jackson, M.V., Chiang, C.Y., Melville, D.S., Leung, K.S.K., Li, J., Zhang, L., Peng, H.B., Gan, X.J., Liu, W.L., Ma, Z.J. & Choi, C.Y. (2020) The southern Jiangsu coast is a critical moulting site for Spoon-billed Sandpiper *Calidris pygmaea* and Nordmann's Greenshank *Tringa guttifer*. *Bird Conservation International* 30: 649-660. doi:10.1017/S0959270920000210
- Ye, N.-H., Zhang, X.-W., Mao, Y.-Z., Liang, C.-W., Xu, D., Zou, J., Zhuang, Z.-M., & Wang, Q.-Y. (2011) 'Green tides' are overwhelming the coastline of our blue planet: taking the world's largest example. *Ecological Research* 26: 477–485. DOI 10.1007/s11284-011-0821-8
- Yim, J., Kwon, B.O., Nam, J., Hwang, J.H., Choi, K. & Khim, J.S. (2018) Analysis of forty years long changes in coastal land use and land cover of the Yellow Sea: The gains or losses in ecosystem services. *Environmental Pollution* 241: 74-84. <https://doi.org/10.1016/j.envpol.2018.05.058>
- Yu, C.Y., Sui, W.N., Liang, B., Bao, C.G. & Ma, M.H. (2022) Temporal trends of heavy metals in the sediments of Bohai Bay in China. *Environmental Monitoring and Assessment* 194: 79. <https://doi.org/10.1007/s10661-021-09747-y>
- Yu, Y. T. (2003) International Black-faced Spoonbill census: 24–26 January 2003. Hong Kong Bird Watching Society, Hong Kong.
- Zhao, B., Zhou, Y.R., Liu, N.N., Yang, K. & Li, J. (2021) The thinking and practice of Marine Ecological Red Line Delineation in China. 3<sup>rd</sup> Global Conference on Ecological Environment and Civil Engineering (GCEECE 2021) *E3S Web of Conferences* 293: 01021. <https://doi.org/10.1051/e3sconf/202129301021>

- Zhao, L. (2018) Reclaiming land to be restricted. *China Daily*.  
[http://english.gov.cn/news/top\\_news/2018/01/18/content\\_281476017712430.htm](http://english.gov.cn/news/top_news/2018/01/18/content_281476017712430.htm)
- Zhao, S.J., Zhao, X.J., Li, C.D., Zhu, A.Y. & Wu, C.W. (2006) Alien fishes of mariculture in China. *Marine Science* 30: 75–80.
- Zhao, Z.-Y., Xu, Y., Yuan, L., Li, W., Zhu, X.-J. & Zhang, L.-Q. (2020) Emergency control of *Spartina alterniflora* re-invasion with a chemical method in Chongming Dongtan, China. *Water Science and Engineering* 13: 24-33.  
<https://doi.org/10.1016/j.wse.2020.03.001>
- Zhang B, Q.Tang, X. Jin (2007) Decadal-scale variations of trophic levels at high trophic levels in the Yellow Sea and the Bohai Sea ecosystem. *Journal of Marine Systems* 67: 304-311.
- Zhang, D., Zhang, X. L., He, J. K. & Chai, Q. M. (2011). Offshore wind energy development in China: current status and future perspective. *Renewable and Sustainable Energy Reviews* 15, 2457–2460. doi:10.1016/ j.rser. 2011
- Zhang, J.S., Zhang, W.S., Zhou, J., Wang, J.H., Xiong, M.J. & Yin, C.T. (2020) Characteristics of storm surge due to typical typhoon tracks in coastal areas of the South Yellow Sea. In: Nguyen, T.V., Dou, X.P. & Tran, T.T. (eds) APAC 2019. APAC 2019. Springer, Singapore. [https://doi.org/10.1007/978-981-15-0291-0\\_4](https://doi.org/10.1007/978-981-15-0291-0_4)
- Zhang, P., Bian, Y., Huo, C.L. & Na, G.S. (2020) Organochlorine pesticides (OCPs) in the marine environment of the China coast. Pp. 42-44 In Alava, J.J., Lukyanova, O.N., Ross, P.S. & Shim, W.J. (Eds.) *Report of Working Group 31 on Emerging Topics in Marine Pollution. PICES Scientific Report No. 56*.
- Zhang, S.-D., Ma, Z., Choi, C.-Y., Peng, H.-B., Bai, Q.-Q., Liu, W.-L., Tan, K., Melville, D.S., He, P., Chan, Y.-C., van Gils, J.A. & Piersma, T. (2018) Persistent use of a shorebird staging site in the Yellow Sea despite severe declines in food resources implies a lack of alternatives. *Bird Conservation International* 28: 534-548. <https://doi.org/10.1017/S0959270917000430>
- Zhang, S.D., Ma, Z., Choi, C-Y., Peng, H-B., Melville, D.S., Zhao, T-T., Bai, Q-Q., Liu, W-L., Chan, Y-C., van Gils, J.A. & Piersma, T. (2019b) Morphological and digestive adjustments buffer performance: how staging shorebirds cope with severe food declines. *Ecology and Evolution* 9: 3868-3878. DOI: 10.1002/ece3.5013
- Zhang, S.D., Ma, Z.J., Feng, C.C., Melville, D.S., van Gils, J.A. & Piersma, T. (2019c) Individual diet differences in a molluscivore shorebird are associated with the size of body instruments for internal processing rather than for feeding. *Journal of Avian Biology* e02255 doi: 10.1111/jav.02255
- Zhang, S.D., Bai, Q.Q., Melville, D.S., Feng, C.C., Zhang, Z.W., Piersma, T. & Ma, Z.J. (2021) Food supplementation as a conservation intervention: A framework and a case of helping threatened shorebirds at a refuelling site. *Biological Conservation* 264: 109394. <https://doi.org/10.1016/j.biocon.2021.109394>

- Zhang, S.P., Xie, S.P., Liu, Q.Y., Ren, Z.P. (2009) Seasonal variations of Yellow Sea fog: Observations and mechanisms. *Journal of Climate* 22: 6758-6772. DOI: 10.1175/2009JCLI2806.1
- Zhang, S. Y., Guo, H., Zhang, S. C., Fan, H. L., & Shi, J. A. (2020) Are oil spills an important source of heavy metal contamination in the Bohai Sea, China? *Environmental Science and Pollution Research International* 27: 3449–3461. <https://doi.org/10.1007/s11356-019-06913-1>
- Zhang, W., Markfort, C.D. & Porté-Agel, F. (2013) Experimental study of the impact of large-scale wind farms on land–atmosphere exchanges. *Environmental Research Letters* 8: 015002. doi: 10.1088/1748-9326/8/1/015002
- Zhang, X.L., Song, Y.J., Liu, D.Y., Keesing, J.K. & Gong, J. (2015) Macroalgal blooms favor heterotrophic diazotrophic bacteria in nitrogen-rich and phosphorus-limited coastal surface waters in the Yellow Sea. *Estuarine, Coastal and Shelf Science* 163 (Part A): 75–81. <https://doi.org/10.1016/j.ecss.2014.12.015>
- Zhang, Y.Y., He, P.M., Li, H.M., Li, G., Liu, J.H., Jiao, F.L., Zhang, J.H., Huo, Y.Z., Shi, X.Y., Su, R.G Ye, N.H., Liu, D.Y., Yu, R.C Wang, Z.L., Zhou, M.J. & Jiao, N.Z. (2019a) *Ulva prolifera* green-tide outbreaks and their environmental impact in the Yellow Sea, China. *National Science Review* 6: 825–838. doi: 10.1093/nsr/nwz026
- Zhang, Z., Xu, N., Li, Y.F. & Li, Y. (2022) Sub-continental-scale mapping of tidal wetland composition for East Asia: A novel algorithm integrating satellite tide-level and phenological features. *Remote Sensing of Environment* 269:112799. DOI: <https://doi.org/10.1016/j.rse.2021.112799>.
- Zhang, Z.Y., Yang, W., Ding, J.W., Sun, T., Liu, H.F. & Liu, C.G. (2022) Identifying changes in China's Bohai and Yellow Sea fisheries resources using a causality-based indicator framework, convergent cross-mapping, and structural equation modelling. *Environmental and Sustainability Indicators* 14: 100171. doi:10.1016/j.indic.2022.100171
- Zhong, N. (2015) China likely to import more iron ore from Vale. *China Daily* 14 February 2015. [https://www.chinadaily.com.cn/business/2015-02/14/content\\_19589085.htm](https://www.chinadaily.com.cn/business/2015-02/14/content_19589085.htm)
- Zhong, H.F., Zheng, M.G., Liang, Y., Wang, Y.J., Gao, W., Wang, Y.W. & Jiang, G.B. 2021. Legacy and emerging per- and polyfluoroalkyl substances (PFAS) in sediments from the East China Sea and the Yellow Sea: Occurrence, source apportionment and environmental risk assessment. *Chemosphere* 282: 131042 <https://doi.org/10.1016/j.chemosphere.2021.131042>
- Zhou, M.-J., Liu, D.-Y., Anderson, D.M. & Valiela, I. (2015) Introduction to the Special Issue on green tides in the Yellow Sea. *Estuarine, Coastal and Shelf Science* 163 (Part A): 3–8. <https://doi.org/10.1016/j.ecss.2015.06.023>
- Zhuang, M., Liu, J., Ding, X., He, J., Zhao, S., Wu, L., Gao, S., Zhao, C., Liu, D., Zhang, J. & He, P. 2021. Sargassum blooms in the East China Sea and Yellow Sea: formation and management. *Marine Pollution Bulletin*, 162, p.111845.

- Zhu, B.-R., Verkuil, Y.I., Conklin, J.R., Yang, A.L., Lei, W.P., Alves, J.A., Hassell, C.J., Dorofeev, D., Zhang, Z.W. & Piersma, T. (2021) Discovery of a morphologically and genetically distinct population of Black-tailed Godwits in the East Asian-Australasian Flyway. *Ibis* 163: 448–462. <https://doi.org/10.1111/ibi.12890>
- Zhu, D.K, Martini, I.P., & Brookfield, M.E. (1998) Morphology and land-use of the coastal zone of the North Jiangsu Plain Jiangsu Province, Eastern China. *Journal of Coastal Research* 14: 591-599.
- Zhu, G.R., Xie, Z.L., Xu, H.L., Liang, M.X., Cheng, J.X., Gao, Y.J. & Zhang, L.G. (2021) Land reclamation pattern and environmental regulation guidelines for port clusters in the Bohai Sea, China. *PLoS ONE* 16(11): e0259516.  
DOI: 10.1371/journal.pone.0259516
- Zhu, Q., Y. P. Wang, W. Ni, J. Gao, M. Li, L. Yang, X. Gong & S. Gao (2016) Effects of intertidal reclamation on tides and potential environmental risks: a numerical study for the southern Yellow Sea. *Environmental Earth Sciences* 75: 1472. DOI 10.1007/s12665-016-6275-0
- Zou, Y.W., Yang, Q., Li, Q.B., Liu, G.Z., Guo, H. & Wang, Z.L. (2013) Community structure and variation of zooplankton in the Northern Yellow Sea. *Marine Environmental Science* 32: 683-687. [in Chinese]
- Zuo, J. C., Yang, Y. Q., Zhang, J. L., Chen, M. X., & Xu, Q. (2013) Prediction of China's submerged coastal areas by sea level rise due to climate change. *Journal of Ocean University of China* 12: 327–334. doi:10.1007/s11802-013-1908-3

## 11 APPENDICES

### Appendix 1. List of globally threatened and near threatened bird taxa which are largely dependent on the Yellow Sea

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Swan Goose	<i>Anser cygnoid</i>	VU	A2bcd+3bcd+4bcd			Yes	4	↓	M	S	Amnok River estuary, Chongchon River estuary and Mundok plain
Red-crowned Crane	<i>Grus japonensis</i>	EN	A2ac+4ac; C1			Yes	5	↓	W	F, S, A	Shuangtaizi estuary and Inner Gulf of Liaodong, Yellow River Delta NNR, Lianyungang coast, Yancheng NNR




<sup>259</sup> <https://www.iucnredlist.org/>




<sup>260</sup> IUCN. (2012). *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. IUCN, Gland, Switzerland and Cambridge, UK.

<sup>261</sup> Only available for shorebirds - Conklin *et al.* (2014).

<sup>262</sup> Mundkur, T. & Langendoen, T. (2022) *Report on the Conservation Status of Migratory Waterbirds of the East Asian – Australasian Flyway Partnership*. First Edition. Report to the East Asian – Australasian Flyway Partnership. Wetlands International, Ede, The Netherlands. <https://www.wetlands.org/eaaf-conservation-status-review/>

<sup>263</sup> As determined in Appendix 4.

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Hooded Crane	<i>Grus monacha</i>	VU	B2ab(i,ii,iii,iv)			Yes	160	?	W	Sc, Sa	Chongchon River estuary and Mundok plain, Boseong-Suncheon tidal flats, Yellow River Delta NNR
Oriental Stork	<i>Ciconia boyciana</i>		C2a(ii)				100	? 	B	Sd, F	Yellow River Delta NNR
Black-faced Spoonbill	<i>Platalea minor</i>	EN	A3ce			Yes	50		B, M,W	R, T	Ganghwa Island, Yeongjong Island, Yeonggwang-Baeksu tidal flats
Chinese Egret	<i>Egretta eulophotes</i>	VU	C2a(i)			Yes	75	St	B	Sa, Mu, W, R	
Dalmatian Pelican	<i>Pelecanus crispus</i>	NT	A3cde				1		W	F, Ma	Yellow River Delta NNR, Lianyungang coast, Tiaozini (Dongtai coast)

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Eurasian Oystercatcher	<i>Haematopus osculans</i>	NT	A2bc+3b+4bc	NT	C1	Yes	110	St	M, B,W	Sa, Mu, R, E	Geum estuary (including Yubu Island), Shuangtaizi estuary and Inner Gulf of Liaodong, Dongling coast
Grey Plover	<i>Pluvialis squatarola</i>	LC		NT (VU)	A2/3/4		800	St ? 	M, W	In	
	<i>Pluvialis squatarola tomkovichi</i>					Yes	45		M	In	
Lesser Sandplover <sup>264</sup>	<i>Charadrius mongolus</i>	LC		EN	A2/3/4	Yes	260	  ?	M	In	Shuangtaizi estuary and Inner Gulf of Liaodong, Tiaozini (Dongtai coast), Rudong coast, Dongling coast
	<i>Charadrius mongolus stegmanni</i>			EN	A2/3/4	Yes	130		M	In	

<sup>264</sup> Wei et al. (2022) Genome-wide data reveal parphyly in the sand plover complex (*Charadrius mongolus/leschenaultii*). *Ornithology* 139: 1-10. <https://doi.org/10.1093/ornithology/ukab085> propose splitting *Charadrius mongolus* into 'Siberian Sandplover' *Charadrius mongolus mongolus* and *C. m. stegmanni* (both in EAAF), and Tibetan Sandplover *Charadrius atrifrons atrifrons*, *C. a. pamirensis* and *C. a. schaferi*.



Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Greater Sandplover	<i>Charadrius leschenaultii</i>	LC		VU	A2/3/4		2,400	St	M	In	
Whimbrel	<i>Numenius phaeopus variegatus</i>	LC		NT	A3/4	Yes	650	St	M	In, Sa	Zhuanghe coast, Yellow River delta NNR
Eurasian Curlew	<i>Numenius arquata orientalis</i>	NT	A2bcd+3bcd+4bcd				1,000	St	M,W	In	
Far Eastern Curlew	<i>Numenius madagascariensis</i>	EN	A2bc+3bc+4bc	VU <sup>265266</sup>	A2/3/4	Yes	350	↓	M	In	Is. Maan mudflat, Is. Honggon mudflat, Geum estuary (including Yubu Island), Yalu Jiang estuary, Yellow River Delta NNR

<sup>265</sup> The Far Eastern Oystercatcher *Haematopus [ostralegus] osculans* likely deserves full species status (Senfeld, T., Shannon, T.J., van Grouw, H., Pajmans, D.M., Tavares, E.S., Baker, A.J., Lees, A.C. & Collinson, J.M. (2020) Taxonomic status of the extinct Canary Islands Oystercatcher *Haematopus meadewaldoi*. *Ibis* 162: 1068-1074. Doi: 10.1111/ibi.12778




<sup>266</sup> Significant population decline since assessment by Conklin et al. (2014)

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Bar-tailed Godwit	<i>Limosa lapponica menzbieri</i>	NT	A2abc+3bc+4abc	VU	A3/4	Yes	1,200	↓	M	In	Yalu Jiang estuary
	<i>Limosa lapponica baueri</i>			VU	A3/4	Yes	1,300	↓	M	In	
Black-tailed Godwit	<i>Limosa limosa melanuroides</i>	NT	A2bcde+3bcde+4bcde	NT			1,600	St ?	M	In	
	<i>Limosa limosa bohaii</i> <sup>267</sup>			?		Yes	?	?	M	In	
Ruddy Turnstone	<i>Arenaria interpres</i>	LC		NT [VU]	A2		300	↓	M	M, Rc	
Great Knot	<i>Calidris tenuirostris</i>	EN	A2bc+3bc+4bc	VU <sup>268</sup>	A3/4	Yes	4,300	↓	M	In	Yalu Jiang estuary, Shuangtaizi estuary and Inner Gulf of Liaodong

<sup>267</sup> Recently described (Zhu, B.-R, Verkuil, Y.I., Conklin, J.R., Yang, A.L, Lei, W.P., Alves, J.A., Hassell, C.J., Dorofeev, D., Zhang, Z.W. & Piersma, T. (2021) Discovery of a morphologically and genetically distinct population of Black-tailed Godwits in the East Asian-Australasian Flyway. *Ibis* 163: 448–462. <https://doi.org/10.1111/ibi.12890> – population status yet to be determined.

<sup>268</sup> Significant population decline since assessment by Conklin *et al.* (2014)

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
Red Knot	<i>Calidris canutus rogersi</i>	NT	A2abc+3bc+4abc	VU	A3/4	Yes	540	St ?	M	In	Luannan-Zuidong coast
	<i>Calidris canutus piersmai</i>			VU	A3/4	Yes	560	? ↓	M	In	
Curlew Sand-piper	<i>Calidris ferruginea</i>	NT	A4abc	VU [EN]	A2/3/4		900	↓	M	In, Sp	Yalu Jiang estuary, Luannan-Zuidong coast
Spoon-billed Sand-piper	<i>Calidris pygmaea</i>	CR	A2abcd; C1+2a(ii)	CR		Yes	8	↓	M, Mo	In	Yancheng NNR, Tiaozini (Dongtai coast), Rudong coast
Dunlin	<i>Calidris alpina actites</i>	LC		VU	D	Yes	9	?	M	In	
Asian Dowitcher	<i>Limnodromus semipalmatus</i>	NT	A2cde+3cde+4cde;C1	NT [VU]	A/C	Yes	280	St	M	In, Sp	Ganyu coast, Lianyungang coast
Grey-tailed Tattler	<i>Tringa brevipes</i>	NT	A2ac+3c+4ac	NT	A	Yes	700	St	M	M, Rc	Yellow River delta NNR, Geum estuary
Spotted Green-shank	<i>Tringa guttifer</i>	EN	C2a(i)	EN	C2	Yes	10	St?	M, Mo	In	Lianyungang coast, Tiaozini (Dongtai

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
											coast), Rudong coast, Dongling coast
Saunders's Gull	<i>Saundersilarus saundersi</i>	VU	A3cde+4cde			Yes	340	? 	B,W	Su, Sa, In	Yalu Jiang estuary, Shuangtaizi estuary and Inner Gulf of Liaodong, Yellow River Delta NNR, Dongling coast
Relict Gull	<i>Larus relictus</i>	VU	A3c			Yes	210	 ?	W	In	Yalu Jiang estuary, Huanghua-Cangzhou coast, Tianjin coastal mudflats, Yellow River Delta NNR
Chinese Crested Tern	<i>Thalasseus bernsteini</i>	CR	C2a(i,ii); D			Yes	1		B	R, Ma	Qingdao coast and Jiaozhou Bay, Yeonggwang-Yuksando

Species	Scientific name	IUCN Red List status global population <sup>259</sup>	IUCN Red List criteria <sup>260</sup>	EAAF provisional Red List assessment† <sup>261</sup>	Reason for EAAF listing	Population endemic to EAAF	EAAF 1% threshold <sup>262</sup>	Trend	Use of YSE	Habitat used	Most important sites <sup>263</sup>
											Island & Gochang tidal flat
Pleske's Grasshopper Warbler	<i>Helopsaltes pleskei</i>	VU	C2a(i)			Yes	<sup>269</sup> [25-99]		B	Ri	

Trend codes: Arrow up=increasing, arrow down=decreasing, St=stable, ?=uncertain

Use codes: M= migrating, W=wintering, B=breeding, Mo=moulting

Habitat codes: Sa=sand bars, Mu=mud bars, In=intertidal flats, E=estuaries, F=freshwater wetlands, A=agricultural fields, Ri=rocky islets, Rc=rocky coasts, Ma=open sea, Sp=salt pans, Su=*Suaeda*, Sc=*Scirpus*

---

<sup>269</sup> Pleske's Grasshopper Warbler is not a waterbird and thus the 1% population threshold for the Ramsar Convention Criterion 6 is not relevant, however it should be noted that the estimated global population of this EAAF endemic is small (1% = 25-99) (BirdLife International (2022) Species factsheet: *Helopsaltes pleskei*. Downloaded from <http://www.birdlife.org>)

**Appendix 2 Action Plan by 2030** (Key Y17, Y18, Y19 and Y20 refer to recommendations in the the outcome documents of the international coastal wetland symposia hosted by Yancheng respectively in 2017, 2018, 2019 and 2020)

Objectives	Strategies/action(s)	Stakeholders
<b>GOVERNANCE</b>		
<b>Reduce fragmentation of governance of the coast</b>	<ul style="list-style-type: none"> <li>▪ Put in place an agency under the highest national authorities to ensure comprehensive governance of the coast by all relevant national, subnational and local jurisdiction. This agency should oversee the development and implementation of a national plan for ensuring protection, sustainable management and restoration of coastal ecosystems. There should be clear accountability for unsustainable management of the coasts.</li> </ul>	National ministries with jurisdiction on: biodiversity conservation and management of terrestrial, freshwater and marine environments and species; climate change (energy and adaptation/mitigation), agriculture and spatial planning and local government
<b>Strengthen Yellow Sea transboundary cooperation</b>	<ul style="list-style-type: none"> <li>▪ Institutionalise the IUCN-led Yellow Sea Working Group, including potentially as a regional hub of the World Coastal Forum;</li> <li>▪ Establish and run a regional coordination committee for WH management (potentially EAAFP).</li> </ul>	The three national governments
<b>Strengthen Concerted Cooperative action along the East Asian - Australasian Flyway</b>	<ul style="list-style-type: none"> <li>▪ Continue to develop work with countries along the EAAF, including via the EAAFP for example through its Yellow Sea Task Force.</li> <li>▪ Develop twinning agreements with internationally important sites along the flyway that share the same birds (Y18).</li> </ul>	
<b>Strengthen cooperation with the Wadden Sea</b>	<ul style="list-style-type: none"> <li>▪ Continue to foster links with the Wadden Sea, including through MoUs.</li> </ul>	

Objectives	Strategies/action(s)	Stakeholders
<b>POLICY AND PLANNING</b>		
<b>Halt further coastal land claims</b>	<ul style="list-style-type: none"> <li>▪ Strengthen policies and regulations on land claim and their implementation.</li> <li>▪ Ground truthing and GIS analysis to monitor that no further claims occur.</li> </ul>	Three national governments at the highest level.
<b>Ensure all renewable energy and ports developments are bird friendly.</b>	<ul style="list-style-type: none"> <li>▪ Reduce authority of local governments so as to exert greater national control of project approval.</li> <li>▪ Improve EIA processes and the subsequent planning and interventions for all major developments – ports, wind farms and others. Improve EIA procedures giving high priority to biodiversity, including migratory birds and fisheries.</li> <li>▪ Renewable energy installations, especially wind farms, and associated power transmission infrastructure, must be located and designed to minimize impacts on birds (Y18).</li> </ul>	Planners and regulators of all three countries, supported by strict law enforcement.
<b>Mainstream conservation of coastal wetlands and associated ecosystem across sectors and promote their value as nature-based solutions to food security, and climate change adaptation mitigation and adaptation.</b>	<ul style="list-style-type: none"> <li>▪ Foster synergies between sectors and stakeholders that stand to gain from sustainable management of the Yellow Sea ecosystem.</li> </ul>	
<b>Explore the better integration of Yellow Sea wetlands in national and global blue carbon strategies</b>	<ul style="list-style-type: none"> <li>▪ Demonstrate the contribution of coastal wetland ecosystems in terms of resilience and mitigation to climate change at local, national and global</li> </ul>	

Objectives	Strategies/action(s)	Stakeholders
	levels including, but not limited to, their contribution to the National Determined Contributions under the Paris Agreement.	
<b>Control release of upstream pollutants from point sources and general land-use practices</b>	<ul style="list-style-type: none"> <li>▪ Identify point sources, strengthen general agricultural practices to prevent agricultural run off, and better control the use of harmful chemicals.</li> </ul>	Departments of Industry, Agriculture and Water Works of the three countries.
<b>Increase shipping safety to prevent oil spills</b>	<ul style="list-style-type: none"> <li>▪ Impose severe fines on companies causing spills.</li> </ul>	All three governments to agree and apply.
<b>Ensure all strategies and plans for the coast are future proof</b>	<ul style="list-style-type: none"> <li>▪ Strategies and plans for the coast must consider predicted and potential changes related to sea level rise and other climate change related effects including increased flood risk, as well as the effect of geomorphological processes including in response to anthropogenic changes to sediment flow.</li> </ul>	
<b>SITE DESIGNATION/PROTECTION</b>		
<b>Fill gaps in PA coverage to secure ecological connectivity for migratory birds.</b>	<ul style="list-style-type: none"> <li>▪ Conduct additional field surveys, use of tracking and ringing data to map connectivity, and gap analysis.</li> <li>▪ All critical gaps filled by some level of protection or improved management.</li> </ul>	National and local governments based on advice from scientific studies.
<b>Complete Yellow Sea WH nominations including all key migratory bird sites</b>	<ul style="list-style-type: none"> <li>▪ Ensure strong Phase II nominations are submitted to the WH Committee for PRC and ROK including all key sites.</li> <li>▪ Provide assistance to DPRK to update their Tentative List, potentially followed by a nomination.</li> </ul>	Three countries State Parties to the WH Convention, international aid providers.
<b>Consider procedures for boundary modifications of</b>	<ul style="list-style-type: none"> <li>▪ Develop and implement guidance to adjust protected area boundaries as necessary to future proof them against geomorphological and climate</li> </ul>	



Objectives	Strategies/action(s)	Stakeholders
<b>coastal sites available under the World Heritage (and Ramsar) Convention(s); and EAAFP</b>	change related factors, including to maintain connectivity for migratory waterbirds	
<b>MANAGEMENT</b>		
<b>Complete and implement management plans to international standards for all key sites, to include restoration</b>	<ul style="list-style-type: none"> <li>▪ Management plans need to be evidence-based and inclusive (e.g. deliver both safe and disturbance- free suitable feeding, roosting and nesting sites for waterbirds) and build in stakeholder and local community participation (Y20, Y19)</li> <li>▪ Embed site plans into wider land-use and development plans</li> <li>▪ Ensure budgetary processes for all protected areas includes investment in manpower, including capacity building, to undertake sustainable management, rather than just investment in infrastructure and equipment.</li> </ul>	Three governments at national and local levels
<b>Ensure that all important coastal shorebird feeding tidal flats have safe high-tide roosting areas for birds</b>	<ul style="list-style-type: none"> <li>▪ All key protected areas to study where migrating bird flocks rest at high tide, which may vary throughout the annual cycle, and ensure they are protected, appropriately managed and sufficient, creating new roost sites where there is inadequate space for the birds.</li> </ul>	Managers of all PAs to ensure that there are sufficient suitable higher ground areas for birds to roost during high tide
<b>Adopt suitable management for working coastal wetlands such as shellfisheries, salt pans, aquaculture and mariculture, including controls on practices harmful to biodiversity.</b>	<ul style="list-style-type: none"> <li>▪ Develop and apply evidence-based guidance on how to manage working coastal wetlands including shellfisheries, salt pans, aquaculture and mariculture for the benefit of both waterbirds and the local economy.</li> <li>▪ New sets of control regulations supported by law enforcement</li> </ul>	Three governments at national and local levels

Objectives	Strategies/action(s)	Stakeholders
<p><b>Ensure tourism is sustainable and develop ecotourism including showing people wild birds in their habitats in a disturbance free way that does not harm the wetland habitat.</b></p>	<ul style="list-style-type: none"> <li>▪ Strengthen management to prevent new tourism infrastructure and visitors negatively impacting the wetland.</li> <li>▪ Draw visitors to the region not only for its wildlife but also its healthy environment and the quality of the ecotourism experience itself, adopting an ‘ecotourism’ standard in line with IUCN guidelines, where experiencing the wetland’s environment and the wildlife it supports are an integral part of the tourism experience. (Y17)</li> <li>▪ Compile and disseminate evidence on how to show people wild birds in their habitat in such a way that the wildlife is not disturbed.</li> <li>▪ Consider establishing an eco-tourism trail around the Yellow Sea coast, linking visitor centres with a shared narrative.</li> </ul>	<p>Local site managers in line with national guidelines</p>
<b>RESTORATION</b>		
<p><b>Develop national plans for coastal wetland restoration to identify which areas can be restored to replace wetland loss</b></p>	<ul style="list-style-type: none"> <li>▪ All three nations to undertake mapping exercises of their entire coast to identify priority areas for coastal wetland restoration e.g. using methodology similar to the Royal Society for the Protection of Birds (RSPB) Sustainable Shores Conservation Project for the UK.</li> <li>▪ A network of multi-functional feeding, roost and nesting sites should be created and maintained at regular intervals along the Yellow Sea coast to provide both safe and disturbance-free foraging, roost and nesting sites for waterbirds (Y20).</li> <li>▪ <i>Each country has mapped priority areas to restore with an implementation plan to restore sufficient coastal ecosystems to replace all past anthropogenic losses and those predicted by sea level rise by the year 2050.</i></li> </ul>	<p>All three countries.</p>

Objectives	Strategies/action(s)	Stakeholders
<b>Ensure effective wetland restoration through use of evidence-based guidance and international best practice</b>	<ul style="list-style-type: none"> <li>▪ All three nations undertake restoration of prioritised sites through the use of evidence-base guidance and international best practice, such as those being developed by Wetlands International and the World Coastal Forum.</li> <li>▪ <i>Each country has developed and implemented site restoration plans to restore sufficient coastal ecosystems to replace at least 50% of the anthropogenic losses over the past three decades.</i></li> </ul>	All three countries.
<b>SPECIES CONSERVATION: NON SITE-BASED APPROACHES</b>		
<b>Limit overfishing</b>	<ul style="list-style-type: none"> <li>▪ Adopt closed seasons; ban destructive tackle; reduce the number of vessels</li> <li>▪ Fish catches per unit effort stabilize</li> </ul>	Three governments to apply independently.
<b>Develop action plans for key species such as seals, porpoises and turtles.</b>	<ul style="list-style-type: none"> <li>▪ Evidence-based plans to be developed</li> <li>▪ Species monitoring shows recovering populations</li> </ul>	Local experts and officials, managers and NGOs
<b>Implement a coordinated evidence-based eradication plan from the whole Yellow Sea of <i>Spartina</i>, and other Invasive Alien Species as appropriate</b>	<ul style="list-style-type: none"> <li>▪ Raise awareness about the negative impacts of Invasive Alien Species.</li> <li>▪ Adopt policies of eradication with agreed national eradication strategies and local action plans.</li> <li>▪ <i>Spartina</i> absent from the entire Yellow Sea coast by 2030.</li> </ul>	Three countries involving governments, public and site managers
<b>MONITORING, RESEARCH AND DATA SHARING</b>		
<b>Key knowledge gaps filled by sound research</b>	<ul style="list-style-type: none"> <li>▪ Undertake a three-country exercise to identify the top research questions that need to be answered to improve the conservation status of the Yellow Sea coastal ecosystem and its migratory waterbirds.</li> </ul>	Governments and funding agencies target funding towards key topics

Objectives	Strategies/action(s)	Stakeholders
	<ul style="list-style-type: none"> <li>▪ Strengthen and develop well-coordinated multi-disciplinary research programmes to improve understanding of ecological relationships and solutions (Y20)</li> <li>▪ Increased number of publications;</li> <li>▪ Gaps in knowledge are addressed and help to identify key solutions.</li> </ul>	
<b>Increase knowledge of pollution</b>	<ul style="list-style-type: none"> <li>▪ Promote monitoring of pollution and open reporting and information sharing</li> </ul>	All three countries organise their own monitoring but share data.
<b>Development of a Yellow Sea collaborative platform for sharing and reporting monitoring data and other information (Y20)</b>	<ul style="list-style-type: none"> <li>▪ Strengthen and develop well-coordinated year round waterbird monitoring (Y20)</li> <li>▪ Support and contribute to the development of compatible standards and monitoring methods for waterbird and wetland monitoring being developed by the Waterbird Monitoring Task Force of the EAAFP.</li> <li>▪ Adopt compatible standards and monitoring methods for waterbird and wetland monitoring.</li> <li>▪ Waterbird and wetland monitoring system in place and data sharing platform operational</li> </ul>	Entire EAAF, not merely EAAFP member sites
<b>Contribute to the development of, and deploy, compilations of conservation evidence such as the online World Coastal Ecosystem Conservation Toolkit to be</b>	<ul style="list-style-type: none"> <li>▪ Contribute to compilations of management and restoration evidence for intertidal wetlands and associated habitats, conversion of this into guidance documents and dissemination and deployment of this guidance.</li> <li>▪ Evidence-based conservation interventions are deployed, avoiding wasting resources on ineffective measures.</li> </ul>	All researchers and conservation practitioners

Objectives	Strategies/action(s)	Stakeholders
developed through the World Coastal Forum		
<b>CAPACITY BUILDING AND SUSTAINABLE FINANCING</b>		
<b>Ensure adequate technical capacity for planning, management, protection and restoration</b>	<ul style="list-style-type: none"> <li>▪ Complete capacity needs assessments using METT index.</li> <li>▪ Capacity building is likely to be needed for effective management of coastal wetlands for waterbirds and other biodiversity.</li> </ul>	All governments and technical institutes supported by international programmes
<b>Ensure sustainable financing for management including from private sector</b>	<ul style="list-style-type: none"> <li>▪ Management plans approved; capacity development plans funded.</li> <li>▪ Business engaged in coastal wetland maintenance and restoration.</li> </ul>	Ministries and bureaus of finance; industry contribution; international support.
<b>COMMUNICATION, EDUCATION AND PUBLIC AWARENESS</b>		
<b>Build local and national awareness of and pride in the Yellow Sea coastal wetlands, and raise awareness of their importance internationally, including to encourage tourism</b>	<ul style="list-style-type: none"> <li>▪ Wetland centres can implement education, ecological tourism, and monitoring, demonstrating and refining sustainable development principles, balancing world class visitor experiences with sensitively managing reserves for wildlife, and become models for wetland conservation and solutions. (Y20)</li> <li>▪ Develop, implement and/or strengthen awareness and outreach programmes at local, national and international levels, emphasizing the importance of the Yellow Sea intertidal wetlands and associated ecosystem services, with a particular focus on policy makers and developers at local, provincial and national levels, using existing Communication, Education, Participation and Awareness (CEPA) programmes.</li> </ul>	Community members, schools, educators, government CEPA focal points

### **Appendix 3. List of relevant major international/domestic programmes**

#### **Asian Development Bank (ADB) (<https://www.adb.org/>)**

At CBD COP15 in October 2021, the Asian Development Bank, BirdLife International and the EAAFP launched a new Regional Flyway Initiative (RFI), a long-term program to protect and restore EAAF wetland ecosystems and the services they provide. This will be accomplished through partnerships among governments, nongovernment organizations, communities, regional organizations, development agencies, the private sector, and other stakeholders. It will build on and collaborate with past and ongoing activities in the EAAF to ensure that opportunities for synergy are realized and duplication of efforts is avoided. Migratory waterbirds will provide a focus for RFI activities, as firstly their use of wetlands across the EAAF makes them the perfect barometer for regional and global environmental change, and secondly waterbirds international appeal provides the perfect species group to capture the public imagination and so increasing further buy-in to protect and sustainably manage these wetlands as a “string of pearls” for generations to come.

The RFI will initially target 10 East and Southeast Asian countries, where a network of around 50 priority wetland sites will be identified based upon their value for migratory bird species, critical ecosystem service management co-benefits and the key actions needed for their protection. Financing mechanisms will be developed under the RFI for loans to national governments and grants to civil society. These will aim to raise and mobilize finance of at least \$3 billion over the next 10–20 years to support and build on the objectives of the EAAFP Strategic Plan 2019–2028 and deliver projects that strengthen the protection and sustainable management of the network of priority wetlands. The RFI will also provide support to address institutional capacity needs and strengthen regional cooperation within the flyway.

#### **BirdLife International (<https://www.birdlife.org/>)**

In 1993 the International Council for Bird Preservation (ICBP) became BirdLife International and the BirdLife Partnership was born. It has grown to a partnership of 120 Partners organizations. The BirdLife Partnership works to realize a world where nature and people live in greater harmony, more equitably and sustainably. It strives to conserve birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources. BirdLife aims to: prevent extinction in the wild; maintain and where possible improve the conservation status of all bird species; conserve the sites and habitats important for birds and other biodiversity; sustain the vital ecological system that underpin human livelihoods, and enrich the quality of people's lives and in the process, empower people and contribute to the alleviation of poverty, and strive to ensure sustainability in the use of natural resources. BirdLife International undertakes and publishes many studies; compiles, for IUCN, the Bird Red List and acts as the bird specialist group under the IUCN Survival Service Commission. It also manages the Endemic Bird Areas, Important Bird and Biodiversity Areas (IBA) and Key Biodiversity Areas (KBA) programmes. In PRC, the BirdLife Asia Partnership promotes the formation of bird clubs in many cities and provinces, and also works with government, schools and communities. BirdLife is also a partner of EAAFP.

#### **Birds Korea (<http://www.birdskorea.org/BK-Startpage.shtml>)**

Birds Korea is a small organization dedicated to the conservation of birds and their habitats in Korea and the wider Yellow Sea Eco-region. Founded in 2004, it is an independent Korean NGO that works through research, planning and education, in the belief that conservation of

biodiversity is a key element of genuinely sustainable development (benefiting people as well as other species); and that decision-makers need best information if they are to make wise decisions that are in both the national and global interest.

Birds Korea has published Status of Birds reports, detailing many of the changes to bird populations within ROK. The organization supports and participates in the EAAFP and Hanns Seidel Foundation surveys in DPRK and other parts of the EAAF especially Yellow Sea.

**China Ornithological Society (COS) (<http://www.chinabird.org/jianjie-en.htm>) and China Bird Watching Network (<http://www.chinabirdnet.org/>)**

The China Ornithological Society (COS) is the leading NGO working on ornithology and bird conservation, aiming to develop ornithology in PRC, set up a nation-wide network and promote international cooperation in research and conservation actions for the threatened species of birds living in the country.

Most of the COS members are professional ornithologists working at universities, research institutes and natural history museums. COS has four Specialist Groups of which two - Waterbird and Crane Specialist Group and Bird Banding Specialist Group are active in the Yellow Sea conservation in the national bird-banding programme, conducting annual bird surveys and publishing reports and newsletters. They publish an annually updated China Bird Report with compiled and vetted bird records, based on bird watchers' observations.

The China Bird Watching Network links the many regional bird watching societies that now emerge in PRC and contributes many of their records to the China Bird Report.

**Convention on the Conservation of Migratory Species of Wild Animals (CMS) (<https://www.cms.int/>)**

As an environmental treaty of the United Nations, CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range. Migratory species threatened with extinction are listed on Appendix I of the Convention. CMS promotes concerted action among the Range States of many of these species. Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. For this reason, the Convention encourages the Range States to conclude global or regional agreements. None of the three Yellow Sea countries are members but PRC has signed some of the MOU's under the convention. CMS complements and co-operates with a number of other international organizations, NGOs and partners in the media as well as in the corporate sector.

**East Asian-Australasian Flyway Partnership (EAAFP) (<https://www.eaaflyway.net/>)**

The EAAFP was launched on 6 November 2006. It aims to protect migratory waterbirds, their habitats and the livelihoods of people dependent upon them. There are currently 39 Partners including 18 national governments, 6 intergovernmental agencies, 13 international NGOs, 1 international organisation and 1 international private enterprise. The ROK joined EAAFP since 2006, the PRC since 2008 and the DPRK since April 2018). The Partnership provides a flyway wide framework to promote dialogue, cooperation and collaboration between a range of stakeholders to conserve migratory waterbirds and their habitats. Stakeholders include all levels of governments, site managers, technical institutions,

UN agencies, development agencies, industrial and private sector, academe, NGOs, community groups and local people. As part of the EAAFP's work, a dedicated Task Force for the Yellow Sea has been formed.

**Eco-Horizon Institute of ROK (EHI) (<https://ecoin.or.kr/>)**

The Eco-Horizon Institute of Korea (EHI) is an NGO-based environmental research institute that was established in 2006 for the purpose of constructing an ecological society where the values of ecological autonomy, responsibility, and diversity are respected and the ideals of peace and sharing are realized. To this end, it is working to protect the natural environment, conducting social research for sustainable living, establishing and exchanging environmental conservation measures between ROK and DPRK, and pursuing international solidarity for global environmental conservation. In particular, it has dedicated itself to the preservation of the Yellow Sea tidal flats, strengthened community-based activities and the role of the visitor centres, supported Korea's marine protected area policy, and participated in the Phase 1 World Heritage nomination-writing process.

**Global Flyway Network (<https://www.globalflywaynetwork.org>)**

The Global Flyway Network (GFN) is a partnership between researchers worldwide who are devoted to long term - usually demographic - work on long-distance migrating shorebirds. In 2006, Prof. Dr Theunis Piersma and Prof. Dr Allan J. Baker procured international funding through BirdLife Netherlands to establish the non-profit network to better understand and help conserve migratory shorebirds in a rapidly changing world. The GFN partnership applies the strengths of comparative demographic and migration tracking shorebird studies worldwide, with the aim to understand and analyse the factors determining shorebird numbers in a rapidly changing world. In practice it also tries to fill major gaps in coverage of fieldwork of the world's most threatened shorebirds. GNF has partners along all major flyways including the EAAF where our research efforts have made major contributions to better understanding of shorebird migration connectivity, assessing population trends and identifying drivers of change, which in turn have contributed to the identification of sites of international importance and delineation of boundaries of protected areas, including World Heritage sites.

**Hanns Seidel Foundation (<https://www.hss.de/en/about-us/our-mission/>)**

The Hanns Seidel Foundation was founded in 1967 to help promote the democratic and civic education of the German people. Its commitment to democracy, peace, and development abroad also rests on these foundations. Hanns Seidel Foundation Korea is carrying out a project on sustainable reforestation in DPRK and there supports and participates in wetland bird surveys and conservation training.

**Hong Kong Bird Watching Society (HKBWS)**

**([https://www.hkbws.org.hk/web/eng/index\\_eng.htm](https://www.hkbws.org.hk/web/eng/index_eng.htm))**

HKBWS was established in 1957. Besides publishing bulletins and the Hong Kong Bird Report regularly, HKBWS organizes birdwatching tours and indoor meetings. HKBWS helps manage the Mai Po Nature Reserve with its wetland managers' training facility, updates the Hong Kong Bird List and set up the HKBWS China Conservation Fund in 1999 to support the birdwatching promotion and research works of birdwatchers and ornithologists throughout PRC. HKBWS has been cooperating with more than 20 institutions and organizing birdwatching courses at different levels to promote birdwatching in Hong Kong. Besides, conducting bird surveys and



researches, managing important bird habitats and helping the establishment and development of birdwatching societies on the PRC mainland. In 2005, HKBWS cooperated with BirdLife to launch the China Programme to encourage birdwatching activities in the PRC mainland.

### **Important Bird and Biodiversity Areas (IBA)**

(<https://www.birdlife.org/worldwide/programme-additional-info/important-bird-and-biodiversity-areas-ibas>)

The IBA (Important Bird Areas) programme is run by BirdLife International. IBAs are: places of international significance for the conservation of birds and other biodiversity; recognised world-wide as practical tools for conservation; distinct areas amenable to practical conservation action; identified using robust, standardised criteria; sites that together form part of a wider integrated approach to the conservation and sustainable use of the natural environment. BirdLife International has, to date, identified and documented more than 13,000 sites in over 200 countries and territories worldwide, as well as in the marine environment.

### **International Crane Foundation (ICF) (<https://www.savingcranes.org>)**

The International Crane Foundation works worldwide to conserve cranes and the ecosystems, watersheds, and flyways on which they depend. ICF provides knowledge, leadership, and inspiration to engage people in resolving threats to cranes and their diverse landscapes. Based in Wisconsin, USA, the foundation maintains a regional base in PRC and share program offices with partner organizations in Cambodia, India, South Africa, Texas, Vietnam, and Zambia. ICF's approximately 80 staff work with a network of hundreds of specialists in over 50 countries on five continents. ICF is committed to a future where all 15 of the world's crane species are secure. Through the charisma of cranes, ICF envisions a future where people work together to protect and restore wild crane populations and the landscapes they depend on – and by doing so, find new pathways to sustain water, land, and livelihoods.

### **International Union for Conservation of Nature (IUCN) (<https://www.iucn.org/>)**

IUCN is a membership Union composed of both government and civil society organisations. It harnesses the experience, resources and reach of its more than 1,400 Member organisations and the input of more than 18,000 experts. This diversity and vast expertise makes IUCN the global authority on the status of the natural world and the measures needed to safeguard it.

Experts are grouped under a number of different commissions of which the Species Survival Commission and the World Commission on Protected Areas are most relevant to the conservation of the Yellow Sea Ecosystem. Additionally, IUCN serves as Advisory Body to UNESCO's World Heritage Committee and is responsible for review and evaluation of all properties nominated under natural criteria.

The Yellow Sea region falls under the IUCN Asia Regional Office, which has established the specific Yellow Sea Task Force under which this review is conducted.

### **Key Biodiversity Areas Programme (KBA) (<http://www.keybiodiversityareas.org/>)**

The KBA Programme supports the identification, mapping, monitoring and conservation of KBAs to help safeguard the most critical sites for nature on our planet – both terrestrial and marine. The Key Biodiversity Area Partnership is a partnership of 13 global conservation organizations. To date, the partnership and other interested groups have mapped more than

16,000 KBAs worldwide, safeguarding important populations of more than 13,100 species of conservation concern.

**Paulson Institute (<https://www.paulsoninstitute.org/>)**

Founded in 2011 by former Treasury Secretary Henry M. Paulson, Jr., the non-partisan Paulson Institute is based in Chicago with offices in Washington and Beijing. This is an independent “think and do tank” dedicated to fostering a US-China relationship that serves to maintain global order in a rapidly evolving world. By working together as a diverse team of experts, the institute delivers solutions that contribute to a more resilient and sustainable world in the belief that the work on issues of consequence for US-China relations and beyond will have lasting significance for the health and prosperity of generations. The focus on US-China is dictated by the reality that it is the most consequential bilateral relationship in the world. The institute operates at the intersection of economics, financial markets, and environmental protection by promoting market-based solutions to ensure green economic growth. Leading analysis and intellectual products are aimed at decoding PRC’s political economy and finding market-based solutions to climate change and environmental conservation. One important program undertaken by the Institute is the Identification of priority sites for conservation along PRC’s coast and publication of the Blueprint of Coastal Wetland Conservation and Management in PRC.

**PūkoROKoro Miranda Naturalists’ Trust (<https://shorebirds.org.nz/>)**

PūkoROKoro Miranda Naturalists’ Trust is an independent charitable trust based in New Zealand. Its initial focus was ‘Promotion and advocacy on the conservation of shorebirds and the ecology of the Miranda coast in Firth of Thames, and the facilitation of such research and education’ but since 1999 it has actively been very actively involved in conducting shorebird surveys and training in PRC at Yalujiang, Liaoning and in DPRK.

**Ramsar Convention (<https://www.ramsar.org/>)**

The Convention on Wetlands, known as the Ramsar Convention, is an intergovernmental environmental treaty established by UNESCO and hosted by IUCN. It provides for national action and international cooperation regarding the conservation of wetlands, and wise sustainable use of their resources. Ramsar sites are wetlands of international importance designated under this Convention. There are currently 2424 Ramsar sites around the world, and 171 national governments are currently participating. All three Yellow Sea countries are members. Each member country forms its own Ramsar Committee which helps select and propose sites to be added to the programme. Sites must meet strict criteria developed under the convention. There are currently eleven Ramsar sites along the Yellow Sea coast that contain tidal flats (five in the PRC, five in the ROK and one in the DPRK).

**Ramsar Regional Center- East Asia (RRC-EA) (<http://rrcea.org/>)**

The RRC-EA is one of the regional initiatives formally recognized by the Ramsar Convention. As a Ramsar Regional Initiative (RRI), the RRC-EA was established through the initiative of the Ministry of Environment of the Republic of Korea to serve as a regional platform for capacity building, information exchange, and cooperation among governments, Ramsar Site and wetland managers and stakeholders, international and national non-government organizations, technical experts and business organizations.

The RRC-EA works with the 18 countries in East, Southeast and South Asia that are Contracting Parties of the Ramsar Convention (Bangladesh, Bhutan, Cambodia, PRC, Democratic People's Republic of Korea, India, Indonesia, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, and Viet Nam) and collaborates also with non-Contracting Parties in the region for further implementation of the Ramsar Convention.

**Royal Society for the Protection of Birds (RSPB) (<https://www.rspb.org.uk/>)**

The Society for the Protection of Birds was founded in 1889 with an initial aim to prevent bird plumage being used for hat ornamentation. The movement grew so much, that in 1904 the society was awarded a Royal Charter, making it the Royal Society for the Protection of Birds. Eventually, the 1921 Importation of Plumage (Prohibition) Act was passed, marking the RSPB's first successful campaign for nature. Today the Society has more than one million members in Britain and engages in all forms of bird conservation. RSPB is the United Kingdom partner of BirdLife International. The work of RSPB stretches far beyond the UK. Wherever wildlife is in threat, they will work with partners to help save it and give it a home. With their partners in BirdLife International RSPB has been deeply involved in the conservation work in the Yellow Sea, the promotion of the World Heritage nominations of PRC and ROK, a partner of EAAFP and supporter of the programme to save the Spoon-billed Sandpiper.

**UNDP Yellow Sea Large Marine Ecosystem Phase II project (<https://iwlearn.net/iw-projects/4343>)**

The YSLME Phase II project, "Implementation of the Yellow Sea LME Strategic Action Programme for Adaptive Ecosystem-Based Management", was launched in 2014, under UNDP with GEF funding, to implement an earlier Phase I project. This project had a December 2020 full completion date. The project objective is to 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. The project had four components: 1. Ensuring sustainable regional and national cooperation for ecosystem-based management, based on strengthened institutional structures and improved knowledge for decision making; 2. Improving Ecosystem Carrying Capacity with Respect to Provisioning Services. Component 3. Improving Ecosystem Carrying Regulating and Cultural Services and 4. Improving Ecosystem Carrying Capacity with Respect to Supporting Services. The project resulted in the release of an important report 'Transboundary Diagnostic Analysis for the Yellow Sea Large Marine Ecosystem (2020)'.

**Wetlands International (<https://www.wetlands.org>)**

Wetlands International is a science-based organisation and partner of local communities, governments and the private sector, with expertise in managing water and wetlands for people and nature. They are the leading international non-profit organisation dedicated to the conservation and restoration of wetlands. The organization's vision is a world where wetlands are treasured and nurtured for their beauty, the life they support and the resources they provide. Its mission is to inspire and mobilise society to safeguard and restore wetlands for people and nature. Its ambition for the period 2020-2030 is to upscale action to safeguard and restore wetlands, collaborating with multiple partners and mobilising a wide range of actors to transform whole landscapes and sectors.

Wetlands International is dedicated to maintaining and restoring wetlands— for their environmental values as well as for the services they provide to people, working through our network of offices, partners and experts to achieve these goals. The organization’s work is financed on a project basis by governments and private donors and by government and NGO membership. Wetlands International maintains a programme of identifying and updating information about priority wetland areas.

Wetlands International has a number of important programmes in the region: One is the annual Asian Waterbird Census implemented in all countries in the flyway that provides monitoring information on waterbirds at many important sites. In addition, it has produced the 1st edition of the EAAF Conservation Status Review (CSR) in July 2022 which provides new size estimates, trends and 1% thresholds for 276 biogeographic populations. The CSR has been produced in collaboration with EAAF Partners, Working Groups and experts across the flyway. The Flyway Bottleneck Yellow Sea project focusses on evidence-based restoration of habitats for migratory waterbirds in the EAAF, with a focus on the Yellow Sea. Also the Building with Nature – Asia program does important work in the region, accelerating adaptation by integrating nature based solutions into water related infrastructure and building climate resilient landscapes with multiple benefits to people and nature.

**The Wildfowl & Wetlands Trust (WWT) (<https://www.wwt.org.uk/>)**

Set up in 1946 at Slimbridge, U.K. as a centre for science and conservation, WWT conserve, restore and create wetlands, save wetland wildlife, and inspire the public to value the amazing things healthy wetlands achieve for people and nature. We believe wetlands are key in helping us meet our most pressing environmental challenges. WWT helps manage wetlands sustainably, so they support livelihoods, local economies plus health and wellbeing. In many countries around the world, where wetlands, wetland nature and peoples’ livelihoods are threatened, WWT deliver community-led and sustainable solutions, and ensure wetlands are more effectively valued and considered in local, regional and national decision making. Key international decision makers must value wetlands and WWT aims to build a global community of highly skilled individuals creating and managing wetlands and mobilising wetland support. WWT has been involved in several aspects of Yellow Sea conservation including efforts to save the critically endangered Spoon-billed Sandpiper.

**World Heritage Convention (<https://whc.unesco.org/en/>)**

The “Convention Concerning the Protection of the World’s Cultural and Natural Heritage” was adopted in 1972 and is administered by UNESCO’s World Heritage Centre fulfilling the role as the Convention’s Secretariat. World Heritage properties are designated for their Outstanding Universal Value to humanity under cultural and/or natural criteria. To be selected, a World Heritage nomination must demonstrate global significance of its values and that it meets highest standards for integrity, protection and management. As of 2022, a total of 1,157 World Heritage properties (900 cultural, 218 natural, and 39 mixed properties) across 167 countries are inscribed on the UNESCO World Heritage List. The UNESCO World Heritage Committee, composed of 21 States Parties that are elected by the World Heritage Convention’s General Assembly, decides on the inscription of nominated properties on the World Heritage List. IUCN serves the Committee as Advisory Body for natural heritage whilst ICOMOS advises on cultural heritage. Following inscription, the World Heritage properties are monitored by the respective States Parties and the Committee, which is advised by ICOMOS

and IUCN. UNESCO's World Heritage Centre, i.e. the Convention's Secretariat, facilitates these processes. Currently, 194 States have ratified the convention, making it one of the most widely recognised and respected international agreements and the world's most popular cultural programme.

**World Heritage Promotion Team of Korean Tidal Flats (<http://www.ktidalflats-heritage.com/>)**

The World Heritage Promotion Team of Korean Tidal Flats was established in 2014. It aims to promote major Korean tidal-flat areas located in the south-western coast of the Korean Peninsula to be inscribed on the World Heritage List and also to ensure practical management of the inscribed sites. It has been carrying out various activities on conservation and management such as monitoring of geo (morpho) logy, bio- and ecology, socio-culture, establishment of integrated management systems including governance, communication with various stakeholders, raising-awareness, etc. The Promotion Team greatly contributed to large scale expansion of Wetland Protected Areas in 2018 and moreover, oversaw the successful inscription of the Phase I Getbol, Korean Tidal Flats as a World Heritage Site in 2021. The Promotion Team was awarded the Presidential Citation in 2022. It will be developed into a 'Getbol World Natural Heritage Headquarters' with expanded functions and roles for efficient integrated management of Phase I sites and also the nomination of Phase II sites.

#### Appendix 4. List of priority sites for conservation of migratory waterbirds

Code	Site name	Lat	Lon	Ramsar sites	FNS	IBA	Part of existing WH	Proposed by experts (consulted for this report) for WH	Outstanding waterbird populations
<b>DPRK</b>									
1	Amnok River estuary	39.88333	124.28333			KP013			Swan Goose (EN; 30,000; 56%)
2	Is. Maan mudflat	39.8	124.18333						Far Eastern Curlew (EN; 7,000; 20%)
3	Is. Tasa mud and saltflat	39.81667	124.4						
4	Is. Taegye mudflat	39.76667	124.5						
5	Pansong Islands	39.68333	124.43333						
6	Is. Honggon mudflat	39.7	124.81667						Far Eastern Curlew (EN; 4,348; 12%)
7	Is. Kwaksan mudflat	39.58333	125.08333						
8	Is. Taegam and Sogam	39.45	125.11667			KP017			
9	Unmu Islands	39.4	125.1			KP018			
10	Chongchon River estuary	39.55	125.36667	Mundok Migratory	EAAF045	KP019			Swan Goose (EN; 40,000; 74%),

	and Mundok plain			Bird Reserve				
11	Haechang River estuary and Namyang saltworks	39.35	125.4					
12	Kumsong mudflat	38.75	125.15					
13	Onchon plain	38.98333	125.2			KP0 21		
14	Taedong River estuary	38.68333	125.2			KP0 22		
15	Kumsanpho mudflat	38.6	125.083 33			KP0 27		
16	Monggumpho mudflat	38.23333	124.85					
17	Taedong bay	38.05	125.233 33			KP0 28		
18	Ongjin bay	37.86667	125.3			KP0 30		
19	Kangryong reservoir	37.83333	125.45			KP0 31		
20	Is. Ryongmae mudflat	37.76667	125.9			KP0 32		
21	Is. Yokgu mudflat	37.83333	126.216 67					
22	Is. Hambak	37.68333	125.983 33					
23	Ryesong River estuary	37.88333	126.383 33					
24	Panmun plain	37.86667	126.666 67			KP0 33		Greater White-fronted Goose (40,000; 33%)

ROK								
25	Han-Imjin River estuary	37.7	126.666 67	Janghang Wetland	EAAF 028 & EAAF 143	KR0 04		
26	Ganghwa Island	37.58013	126.462 07	Ganghwa Maehwamar eum Habitat*		KR0 05	yes	Black-faced Spoonbill (EN; 624; 12%)
27	Yeongjong Island	37.46904	126.538 64			KR0 06	yes	Black-faced Spoonbill (EN; 671; 13%)
28	Songdo tidal flat	37.36667	126.7	Songdo Tidal Flat	EAAF 145		yes	
29	Siwha lake	37.28333	126.75			KR0 09		
30	Hwaseong wetlands	37.16667	126.8		EAAF 142	KR0 10	yes	
31	Asan Bay	36.9	126.9			KR0 17	yes	
32	Cheonsu Bay	36.61667	126.45		EAAF 046	KR0 18		
33	Geum estuary (including Yubu Island)	36	126.683 33	Seocheon Tidal Flat	EAAF 100 & EAAF 101	KR0 19 & KR0 20	yes	Far Eastern Curlew (EN; 3,707; 11%); Eurasian Oystercatcher (NT; 9,815; 89%)
34	Mangyeong estuary	35.86667	126.666 67			KR0 21		Northern section of Saemangeum, formerly supported >10% of the global populations of Spoon-billed Sandpiper (CR) and Great Knot (EN), but lost most of its value for migratory waterbirds



								following construction of a seawall in 2006
35	Dongjin estuary	35.81667	126.65			KR0 22		Southern section of Saemangeum, formerly supported >10% of the global populations of Spoon-billed Sandpiper (CR) and Great Knot (EN), but lost most of its value for migratory waterbirds following construction of a seawall in 2006
36	Gochang tidal flat	35.55	126.566 67	Gochang and Buan Tidal Flats			yes	
37	Yeonggwang-Baeksu tidal flats	35.26667	126.316 67			KR0 24		Black-faced Spoonbill (EN; 736; 15%)
38	Hampyeong-Muan tidal flats	35.08333	126.416 67	Muan Tidal Flat		KR0 25 & KR0 26		
39	Shinan tidal flat	34.95	126.183 33	Jeungdo Tidal Flat	EAAF 146		yes	
40	Boseong-Suncheon tidal flats	34.83333	127.5	Dongcheon Estuary & Suncheon Bay	EAAF 079	KR0 31	yes	Hooded Crane (VU; 4,596; 29%)

Liaoning Province PRC									
42	Yalu estuary	Jiang	39.83333	124.1		EAAF 043	CN0 62	yes	Far Eastern Curlew (EN; 6,420; 18%); Great Knot (EN; 74,900; 17%); Relict Gull (VU; 2,543; 12%); Saunders's Gull (VU; 2,190; 10%); Bar-tailed Godwit (NT; 67,826; 52%); Curlew Sandpiper (NT; 35,770; 40%)
43	Zhuanghe coast		39.66667	123.033 33			CN0 59		
44	Pulandian- Jinzhou east coast		39.36667	122.3				yes	
45	Dalian Haibin- Lüshunkou National Scenic Area		38.86667	121.666 67					
46	Snake Island- Laotieshan National Nature Reserve		38.76667	121.183 33			CN0 58	yes	
47	Jinzhou Bay, Dalian		39.16667	121.6					
48	Wafangdian Fuzhou Bay		39.65	121.533 33			CN0 55		
49	Shuangtaizi estuary and Inner Gulf of Liaodong		40.9	121.783 33	Shuangtai Estuary	EAAF 004	CN0 52	yes	Siberian Crane (CR; 500; 13%); Red-crowned Crane (VU; 308; 51%); Great Knot (EN; 83,000; 19%); Saunders's Gull (VU; 7,600; 36%); Eurasian Oystercatcher (NT; 14,200; 100%); Common Shelduck

								(40,000; 33%); Lesser Sandplover (6,000; 46%)
<b>Hebei Province PRC</b>								
50	Qinhuangdao coast, including Beidaihe	39.83333	119.51667			CN311	yes	A bottleneck site where large numbers of migratory waterbirds fly through on passage; monitoring during the migration seasons in the 1980s recorded substantial proportions of the global population of Siberian Crane (CR) and the Chinese non-breeding populations of Red-crowned, Hooded and White-naped Cranes (all VU)
51	Luan He estuary and Golden Coast Nature Reserve	39.5	119.25			CN312	yes	
52	Laoting-Caofeidian coast	39.01667	118.73333					
53	Luannan-Zuidong coast	39.1	118.2				yes	Curlew Sandpiper (NT; 80,000; 89%); Red Knot (subspecies <i>piersmai</i> ) (NT; 37,000; 66%);

								Red Knot (subspecies <i>rogersi</i> ) (NT; 29,500; 55%)
54	Nandagang Wetland Nature Reserve	38.5	117.5		EAAF 086	CN3 16	yes	
55	Huanghua- Cangzhou coast	38.43333	117.666 67					Relict Gull (VU; 4,827; 23%)
<b>Tianjin Municipality PRC</b>								
56	Tuanbowa Nature Reserve	38.9	117.1			CN3 18		
57	Beidagang Wetland Nature Reserve	38.75	117.383 33	Beidagang Wetlands		CN3 19		
58	Tianjin coastal mudflats	38.91667	117.75			CN3 20		Relict Gull (VU; 11,000; 52%)
<b>Shan- dong Province PRC</b>								
59	Wudi-Zhanhua- Hekou coast	38.13333	118.2					

60	Yellow River Delta National Nature Reserve	37.96667	118.96667	Yellow River Delta Wetland	EAAF 006	CN3 27	yes	Siberian Crane (CR; 2,200; 55%); Oriental Stork (EN; 880; 13%); Far Eastern Curlew (EN; 3,665; 10%); Red-crowned Crane (VU; 220; 37%); Hooded Crane (VU; 210; 21%); White-naped Crane (VU; 255; 25%); Relict Gull (VU; 4,111; 20%); Saunders's Gull (VU; 8,200; 39%); Dalmatian Pelican (NT; 86; 86%); Mute Swan (LC; 420; 100%); Greylag Goose (LC; 11,020; 73%); Common Crane (LC; 8,800; 73%)
61	Laizhou Bay	37.1	119.4			CN3 28		
62	Rongcheng Swan Nature Reserve	37.25	122.56667			CN3 31		
63	South-east Shandong coast	36.78333	121.46667					
64	Qingdao coast and Jiaozhou Bay	36.18333	120.2			CN3 32		Chinese Crested Tern (in Jiaozhou Bay) (CR; 37; 37%)
<b>Jiangsu Province PRC</b>								
65	Ganyu coast	34.96667	119.2					Asian Dowitcher (NT; 11,000; 40%)

66	Lianyungang coast	34.61667	119.51667			CN3 65		Spotted Greenshank (EN; 122; 12%); Red-crowned Crane (VU; 86; 14%); Asian Dowitcher (NT; 22,432; 80%); Dalmatian Pelican (NT; 63; 63%)
67	Yancheng National Nature Reserve	33.71667	120.51667	Yancheng National Nature Reserve	EAAF 005	CN3 67	yes	Spoon-billed Sandpiper (CR; 221; 28%); Red-crowned Crane (VU; 320; 53%)
68	Dongsha shoals	33	121.23333				yes	
69	Tiaozini (Dongtai coast)	32.75	120.96667	Dafeng National Nature Reserve			yes	Spoon-billed Sandpiper (CR; 144; 18%); Spotted Greenshank (EN; 946; 95%); Dalmatian Pelican (NT; 112; 100%); Lesser Sandplover (LC; 6,600; 51%)
70	Rudong coast	32.51667	121.16667					Spoon-billed Sandpiper (CR; 143; 18%); Spotted Greenshank (EN; 171; 17%); Lesser Sandplover (LC; 3,942; 30%)
71	Dongling coast	32.15	121.45					Spotted Greenshank (EN; 142; 14%); Saunders's Gull (VU; 2,555; 12%); Eurasian Oystercatcher (NT; 3,700; 33%); Lesser Sandplover (LC; 4,500; 35%)
72	Qidong coast	31.93333	121.83333					
73	Qidong Northern Yangtze Estuary Nature Reserve	31.76667	121.56667			CN3 73		

Shang-hai Municipality PRC								
74	Chongming Beitan	31.66667	121.66667			CN374		
75	Chongming Dongtan National Nature Reserve	31.48333	122	Chongming Dongtan Nature Reserve	EAAF002	CN375	yes	
76	Jiuduansha National Nature Reserve	31.21667	121.9			CN376		
77	Nanhui coast	30.93333	121.96667			CN377		

#### Footnotes

\* Ganghwa Maehwamareum Habitat Ramsar site is a small rice-field area that does not include any tidal flats and does not support important congregations of tidal flat obligate waterbirds

#### IUCN-SA Map KEY

**Code:** Site number used on the map;

**Site name:** Name of site (based on names used in source references);

**Lat & Lon:** Central coordinates of site;

**Ramsar sites:** Name(s) of the Ramsar site(s) which overlap with the site (see <https://rsis.ramsar.org/> for more details);

**FNS:** Flyway Network Site(s) designated by the EAAFP which overlap with the site (see <https://www.eaaflyway.net/the-flyway/flyway-site-network/> for more details);

**IBA:** Important Bird and Biodiversity Areas designated by the BirdLife Partnership which overlap with the site (see <http://datazone.birdlife.org/site/search> for more details);

**Part of existing WH:** sites that overlap with component parts of existing World Heritage properties;

**Outstanding waterbird populations:** All of the sites in this Appendix are of ‘international importance’ for waterbirds, in accordance with Criterion 6 of the Ramsar Convention, as they ‘regularly support 1% of the individuals in a population of one species or subspecies of waterbird’. Many of the Yellow Sea wetlands are of outstanding importance for the conservation of migratory waterbird populations. In the table, globally threatened species (Critically Endangered, Endangered or Vulnerable on IUCN Red List) are documented if (according to the data published in the key references below) more than 10% of their flyway (and often global) population has been recorded in a site, and other congregatory species (near threatened or least concern on IUCN Red List) are included if more than 30% of their flyway population has been recorded there. These thresholds are adapted from those used for site prioritisation by the Western Hemisphere Shorebird Reserves Network (WHSRN; see <https://whsrn.org/why-whsrn/is-my-site-eligible/>). The table includes the species name, the IUCN Red List status (CR, EN, VU), the maximum count and the percentage of the flyway population.

## References

- Bai, Q., Chen, J., Chen, Zora, Dong, G., Dong, J., Dong, W., Fu, V. W. K., Han, Y., Lu, G. & Li, J. (2015) Identification of coastal wetlands of international importance for waterbirds: a review of China Coastal Waterbird Surveys 2005-2013. *Avian Research* 6: 1-16.
- Choi, C.-Y., Li, J. & Xue, W.J. (2020) *China Coastal Waterbird Census Report (Jan. 2012–Dec. 2019)*. Hong Kong Bird Watching Society, Hong Kong.
- Conklin, J. R., Verkuil, Y. I. & Smith, B. R. (2014) *Prioritizing Migratory Shorebirds for Conservation Action on the East Asian-Australasian Flyway*. WWF-Hong Kong, Hong Kong.
- DPRK (2018) *A wetland inventory for DPR Korea (2nd edition)*. Pyongyang, DPR Korea.
- Duan, H.L., Xia, S.X., Jackson, M.V., Zhao, N., Liu, Y., Teng, J.K., Meng, Z., Yu, X.B. & Shi, J.B. (2020) Identifying new sites of significance to waterbirds conservation and their habitat modification in the Yellow and Bohai Seas in China. *Global Ecology and Conservation* 22: e01031.
- Duan, H.L., Yu, X.B., Xia, S.X. & Liu, Y. (2022) Conserving unprotected important sites for shorebirds on China’s coasts. *Ecosphere* 13: e3950.
- Jaensch, R. (2013) *New tools for development of the Flyway Site Network: An integrated and updated list of candidate sites and guidance on prioritisation*. Report to Partnership for the East Asian-Australasian Flyway.



National Institute Biological Resources (NIBR), Republic of Korea. Unpublished data.

Peng, H. B., Anderson, G. Q. A., Chang, Q., Choi, C. Y., Chowdhury, S. U., Clark, N. A., Gan, X. G., Hearn, R. D., Li, J., Lappo, E. G., Liu, W. L., Ma, Z., Melville, D. S., Phillips, J. F., Syroechkovskiy, E. E., Tong, M., Wang, S., Zhang, L. & Zöckler, C. (2017) The intertidal wetlands of southern Jiangsu Province, China – globally important for Spoon-billed Sandpiper and other threatened waterbirds, but facing multiple serious threats. *Bird Conservation International* 27: 305-322.

Riegen, A., Melville, D.S., Woodley, K., Ri, S.I., Ju, S.I., Ri, C.J., Ji, H.K. & Ri, C.S. 2018. Coastal shorebird survey in the province of North Pyongan, Democratic People's Republic of Korea, April 2018. *Stilt* 72: 21-26.

Waterbird Network Korea (2020) National monitoring of Black-faced Spoonbills and study on their habitats in Republic of Korea. Incheon, Republic of Korea: EAAFP Secretariat & Incheon City.

Xia, S.X., Yu, X.B., Millington, S., Liu, Y., Jia, Y.F., Wang, L.Z., Hou, X.Y. & Jiang, L.G. (2017) Identifying priority sites and gaps for the conservation of migratory waterbirds in China's coastal wetlands. *Biological Conservation* 210: 72-82.

## Appendix 5. Outstanding research needs

Despite the great increase in the range of research projects addressing the issues of Yellow Sea health and many emerging new scientific papers being published there are a number of topics where more research is urgently needed.

1. SLR models of tidal mudflat change
2. Further higher resolution understanding of risks to coastal infrastructure, coastal ecosystems from cumulative threats (SLR, climate change).
3. Distribution of habitat degradation, such as declining benthic infauna
4. A database of bird populations which are dependent on the Yellow Sea, is something that is not yet being done and urgently needed.
5. Relationships between intertidal mollusc harvesting/aquaculture and shorebirds. There is an urgent need for multi-disciplinary research to investigate shellfish intertidal aquaculture and shorebird feeding (predation). Identify suitable measures to counter negative impacts
6. The issue of subsidising fishers to provide bird food should be looked at - especially at main shorebird staging sites such as Nanpu (Red Knot) and Yalujiang. This would be easier to manage for mollusc feeding species - managing polychaetes for Asian Dowitchers at Lianyungang might be a challenge.
7. Simulation models for the future (similar to what conservationists use for deforestation in the Amazon)
8. Teleconnections – making the link between yellow sea environmental degradation and the root causes (often overseas markets)
9. Changing coastal processes due to land claim and coastal interruption, as well as changed sediment outflows.
10. Subsidence and compaction effects on coastal ecosystems
11. Identification of important moulting grounds for shorebirds
12. Methods to reduce incidental mortality of shorebirds (and others) in commercial fish nets
13. Better studies of distribution, population dynamics and protection of Finless Porpoise
14. Strength of governance arrangements, or investigations of alternatives.
15. Fisheries vulnerability
16. Impact of aquaculture diseases on natural ecosystems
17. Protected area performance

Research into the relationships between molluscs and shorebirds (#5 above) requires field studies to investigate stocking rates, levels of predation, subsequent growth rates to better understand the inter-relationships and enable science-based management planning - e.g. changing the time of seeding out (delayed seeding until after main bird migration period) might reduce the growing season, but there would be reduced predation loss. What would be the impact on prey availability for shorebirds, and the ability to laydown energy stores for migration? Such a project would need to be done at multiple sites such as Zhejiang to assess breeding and spat harvesting (including use of organophosphate insecticides for 'cleaning' tidal flats) as well as Yalujiang for growing on over several years. Such a project would need to be founded on a solid scientific marine ecology and ornithology research base, but selection of field sites and working with local fishers, both field workers and 'big bosses' will be essential for success.

## Appendix 6. Site monitoring needs

There is a growing attention to monitoring all along the EAAF.<sup>270</sup> It is important that sites report their observations to a coordinating centre such as the EAAFP. Data from neighbouring sites can be very important for a site to mobilize its own observers and also in general management. Each site should have a programme of monitoring. An example might include the following.

### A. Routine Monitoring

- i. Climatic conditions (rainfall, temperature and tide levels)
- ii. Distribution of muddy banks and vegetation (remote sensing with ground truthing)
- iii. Extreme climate events (storms, sea surges, droughts, floods etc.)
- iv. Monitoring survey of benthic infauna pollutants, populations etc.
- v. Migrating shorebirds (autumn and spring patterns)
- vi. Breeding success of resident species
- vii. Key mammal populations (Milu, seals and Finless Porpoise) (numbers, distribution and health)

### B. Long term change studies

- i. Coastline changes in very dynamic region (access to and use of remote sense data)
- ii. Vegetation plots (selected long term monitoring plots)
- iii. Photographic points (seasonal and annual photos of same place to monitor change over time)
- iv. Sea level rise (some models predict big changes in sea level with major implications for intertidal zone and wildlife)

### C. Environmental Impact studies

- i. Wind turbines, tidal power plans and solar power structures
- ii. Electric cables
- iii. Electric Pylons (use by raptors and nesting sites for storks, magpies etc.)
- iv. Conversion of fishponds to natural wetland (controls versus different prescriptions)
- v. Milu impacts on vegetation
- vi. Changing landuse patterns (within and outside PA)
- vii. Sea walls (effects on silt redistribution and on birds e.g. Tiaozini case<sup>271</sup>)
- viii. Port and fishing activities (see Dandong/Yalujiang case study)
- ix. Other human activities (poaching, disturbance, collecting, accidental fish net bycatch)
- x. Tourism impacts (design zoning and safe capacity levels for tourist access)
- xi. Pollution and plastic litter (control and clean-up methods)

### D. Studies on special key species

- i. Migrating shorebirds (monthly records throughout whole year; weekly records during peak passage seasons, design monitoring points and routes and protocols). Numbers may reflect suitability of local PAs but also affected by many factors up and down flyway.

---

<sup>270</sup> Si et al. 2021

<sup>271</sup> Chang et al. 2021

- ii. Resident Saunders's Gull and Chinese Crested Tern (documenting dynamic changes in breeding areas and breeding success e.g. new colonies)
- iii. Predation on breeding colonies by racoon dogs etc., especially in ROK
- iv. Wintering Red-crowned Cranes (use of PAs and also feeding outside of PAs; maintaining quarantine between wild and captive populations)
- v. Key migrants (Spoonbill Sandpiper, Far Eastern Curley, Great Knot, Red Knot, Black-tail Godwit, Bar-tail Godwit, Nordmann's Greenshank, Asian Dowitcher). Assess numbers, distribution, timings, and health. Identify any signs of disease, parasites or other issues).
- vi. Use satellite tracking and improved understanding of connectivity.

E. Control of *Spartina* experiments (use controls and treatment plots to design best practices for control and impacts)

Each of these topics requires its own protocol and methodology. Some of the topics are already being monitored. There is a need to evaluate the suitability of current monitoring and suggest improvements.

For other topics a matrix of timing of activities, responsibilities, methods of observation and measurement and channels of reporting and data sharing should be established.

## Appendix 7. Summary of main awareness activities and events since 2012

Country	Year	Activity	Coverage address	Brief details
ROK	2014	Many local awareness activities have been conducted in different important sites in ROK	<a href="https://www.eaaflyway.net/2022/01/10/2021-international-symposium-for-the-hwaseong-wetlands/">https://www.eaaflyway.net/2022/01/10/2021-international-symposium-for-the-hwaseong-wetlands/</a>  <a href="https://www.eaaflyway.net/2022/04/18/gochang_whs_management_roadmap/">https://www.eaaflyway.net/2022/04/18/gochang_whs_management_roadmap/</a>  <a href="https://www.eaaflyway.net/2021/12/24/seochon-whs-workshop-gochang-getbol-centre-visit/">https://www.eaaflyway.net/2021/12/24/seochon-whs-workshop-gochang-getbol-centre-visit/</a>	Highlighting a number of ROK awareness raising activities.
ROK	2021	“Getbol, Korean Tidal Flats” inscribed on UNESCO World Heritage List	<a href="https://www.eaaflyway.net/2021/07/26/getbol_korean-tidal-flats_inscribed_unesco-whs/">https://www.eaaflyway.net/2021/07/26/getbol_korean-tidal-flats_inscribed_unesco-whs/</a>	On 26th July, 2021, the 44th Session of the World Heritage Committee inscribed Getbol, Korean Tidal Flats (ROK) on the UNESCO World Heritage List, recognising the importance of critical habitats of the Yellow Sea for millions of migratory waterbirds that depend on this area as a vital stopover on their migratory journeys from as far away as Australia and New Zealand to breeding grounds in Arctic Russia and Alaska.

Country	Year	Activity	Coverage address	Brief details
Regional (for YS)	2018	EAAFP Sister Site Program e.g. Black-faced Spoonbill linking two cities: Conservation work based on the Sister Site Agreement between Incheon – Hong Kong	<a href="https://www.eaaflyway.net/sister-sites/">https://www.eaaflyway.net/sister-sites/</a>  <a href="https://www.eaaflyway.net/2021/12/31/2021-aaafp-review/">https://www.eaaflyway.net/2021/12/31/2021-aaafp-review/</a>	Incheon – Hong Kong Sister Site Agreement under the Flyway Site Network continued in an active mode. The EAAFP Secretariat facilitated the work through supporting to improve Black-faced Spoonbill (BFS) monitoring data analysis through the national BFS census in Ro Korea, establishing a national Black-faced Spoonbill Conservation Guild and a strong international BFS Network. A few collaborative CEPA products included a promotional video and revision of the WWF-Hong Kong BFS migration game were made. On 17th December, an annual international forum has been organized under the joint effort of the governments of Incheon Metropolitan City and Hong Kong S.A.R
Regional (for YS)	2020	UNDP/GEF YSLME Phase I & II Project	<a href="http://www.yslmep.org/">http://www.yslmep.org/</a> <a href="http://www.yslmep.org/?p=4177">http://www.yslmep.org/?p=4177</a>	The YSLME Phase II Project has set up a Regional Working Group on Governance (RWG-G) to improve regional environmental governance by strengthening institutional, legislative, and financial capacities of the region and the countries. A Habitat Conservation Regional Working Group (RWG-H) has been established The project aim and facilitate establishment of network of MPAs in Yellow Sea.

Country	Year	Activity	Coverage address	Brief details
PRC	2020	PRC Policy: Updated National Key Protected Wild Animal under its Wildlife Protection Law	<a href="https://www.eaaflyway.net/2021/02/22/revised-china-protected-species-list-meaning-for-eaafp/">https://www.eaaflyway.net/2021/02/22/revised-china-protected-species-list-meaning-for-eaafp/</a>	92 species of bird now under Class I protection, and 91 species of waterbirds are included in the list.
PRC	2018-2021	1st PRC Wetland Protection Law	<a href="http://cpc.people.com.cn/n1/2021/1229/c64387-32319488.html">http://cpc.people.com.cn/n1/2021/1229/c64387-32319488.html</a>	Adopted on Dec 24 and will become law on June 1, 2022.
PRC	2019-2022	Capacity and Finance China Coastal Wetland Conservation Network	<a href="http://ccwcn.shidi.org/">http://ccwcn.shidi.org/</a>	Convened by former SFA and Paulson Institute in 2015, covering 11 coastal provinces, over 80 Important wetlands, nature reserves and wetland parks.
PRC	2017 - 2021	UNDP- GEF “Strengthening the Protected Area Network for Migratory Bird Conservation Along the East Asian— Australasian Flyway (EAAF) in PRC”	<a href="https://www.eaaflyway.net/2021/05/18/undp-gef-flyway-project-china/">https://www.eaaflyway.net/2021/05/18/undp-gef-flyway-project-china/</a>	The largest standalone GEF-7 biodiversity project in PRC, Strengthening the Protected Area Network for Migratory Bird Conservation Along the East Asian – Australasian Flyway (EAAF) in PRC, was officially launched, four demonstration sites, Liao River Delta (EAAF004), Yellow River Delta (EAAF006), Chongming Dongtan (EAAF002) and Dashanbao (EAAF0083).
PRC	2016	Launch of the “China Wetland Education Centre Guide for Planning and Practise”_Mangrove Foundation (MCF),	<a href="http://www.shidicn.com/sf_DD075C5B2FD24B83A36372DBBE0EB3A6_151_66FA58E1101.html">http://www.shidicn.com/sf_DD075C5B2FD24B83A36372DBBE0EB3A6_151_66FA58E1101.html</a>	The first “China Wetland Education Centre Guide for Planning and Practise” was published

Country	Year	Activity	Coverage address	Brief details
		Paulson's Institute, Lao Niu Foundation		
PRC	2019	Increase of bird watching societies, Nature NGOs, bird watching events such as bird race	<a href="https://www.researchgate.net/publication/259433332">https://www.researchgate.net/publication/259433332</a> The rapid development of birdwatching in mainland China A new force for bird study and conservation  <a href="http://idealera.com/www.jsbws.org/forum.php?mod=viewthread&amp;tid=3577">http://idealera.com/www.jsbws.org/forum.php?mod=viewthread&amp;tid=3577</a>  <a href="https://www.eaaflyway.net/2016/10/28/latest-yellow-sea-bohai-sea-region-survey-of-waterbirds-highlights-continued-importance-of-this-global-bottle-neck-area/">https://www.eaaflyway.net/2016/10/28/latest-yellow-sea-bohai-sea-region-survey-of-waterbirds-highlights-continued-importance-of-this-global-bottle-neck-area/</a>	Federation of China Bird Watching Associations formed in 2014.



Country	Year	Activity	Coverage address	Brief details
PRC	2019	Citizen Science (e.g. China Coastal Waterbird Census, national monitoring on key species like Spoon-billed Sandpiper, Black-faced Spoonbill, Baer's Pochard)	<a href="https://www.eaaflyway.net/2020/03/27/flyway-story-3-ccwc/">https://www.eaaflyway.net/2020/03/27/flyway-story-3-ccwc/</a>  <a href="https://www.eaaflyway.net/2015/12/29/survey-on-wintering-scaly-sided-mergansers-in-china/">https://www.eaaflyway.net/2015/12/29/survey-on-wintering-scaly-sided-mergansers-in-china/</a>  <a href="https://www.eaaflyway.net/2021/05/26/2021-south-china-sbs-winter-census/">https://www.eaaflyway.net/2021/05/26/2021-south-china-sbs-winter-census/</a>  <a href="https://www.eaaflyway.net/2017/01/31/experience-world-class-yellow-sea-migration-and-support-the-local-conservation-effort/">https://www.eaaflyway.net/2017/01/31/experience-world-class-yellow-sea-migration-and-support-the-local-conservation-effort/</a>  <a href="https://www.eaaflyway.net/2017/01/31/experience-world-class-yellow-sea-migration-and-support-the-local-conservation-effort/">https://www.eaaflyway.net/2017/01/31/experience-world-class-yellow-sea-migration-and-support-the-local-conservation-effort/</a>	Coverage of Citizen Science activities in PRC, which is growing in popularity.

Country	Year	Activity	Coverage address	Brief details
DPRK	2017	Nature Reserve Law of the DPRK	<a href="https://kcna.watch/newstream/1620745287-813218023/protection-of-migratory-birds-brisk-in-dprk/">https://kcna.watch/newstream/1620745287-813218023/protection-of-migratory-birds-brisk-in-dprk/</a>	“The wetland issue was supplemented in the Nature Reserve Law of the DPRK in September 2016 to intensify the protection of migratory birds.”
DPRK	2016-2018	Wetland Inventory for DPR Korea	<a href="https://www.eaaflyway.net/2018/10/24/wetland-inventory-for-dpr-korea/">https://www.eaaflyway.net/2018/10/24/wetland-inventory-for-dpr-korea/</a>  <a href="https://www.eaaflyway.net/2015/06/25/joint-shorebird-survey-of-the-onchon-county-coast-of-dprk-2/">https://www.eaaflyway.net/2015/06/25/joint-shorebird-survey-of-the-onchon-county-coast-of-dprk-2/</a> <a href="https://shorebirds.org.nz/north-korea-may-2015">https://shorebirds.org.nz/north-korea-may-2015</a>	Second edition of the ‘Wetland Inventory for DPR Korea’ was released in 2018 during Ramsar COP13, it identified 24 sites in the West Sea that meet Ramsar listing criteria. PukoROKoro Miranda Naturalist’s Trust from New Zealand contributed information based on the surveys in DPRK since 2009.
DPRK	2015	DPRK submitted bird count data for the AWC	<a href="https://kcna.watch/newstream/1651050373-668293936/survey-and-estimation-of-wetlands-on-east-coast-of-dprk-key-sites-on-aaaf">https://kcna.watch/newstream/1651050373-668293936/survey-and-estimation-of-wetlands-on-east-coast-of-dprk-key-sites-on-aaaf</a>	(Per comm.) DPRK submitted bird count data for the AWC. The Biodiversity Institute of the State Academy of Sciences surveyed and estimated the diversity of waterfowl species in over ten wetlands in the coastal areas of the East Sea of Korea last March in the spring migration period.
DPRK	2021	Publications to promote FNS in DPRK	<a href="https://www.eaaflyway.net/dprk/">https://www.eaaflyway.net/dprk/</a> <a href="https://www.youtube.com/watch?v=j5N1jUrqPCk">https://www.youtube.com/watch?v=j5N1jUrqPCk</a>	About 12 publications has been produced to promote Flyway Network Sites (Kumya and Mundok), Ramsar Site (Mundok and Rason), key species, introduction of waterbirds, videos. A video about Kumya was partly supported by WWF-Hong Kong.

Country	Year	Activity	Coverage address	Brief details
DPRK	2022	Awareness raising in DPRK	<p><a href="https://www.eaaflyway.net/2019/1/05/first-swan-goose-festival-in-dpr-korea-celebrating-world-migratory-bird-day/">https://www.eaaflyway.net/2019/1/05/first-swan-goose-festival-in-dpr-korea-celebrating-world-migratory-bird-day/</a></p> <p><a href="https://www.eaaflyway.net/2021/05/26/wmbd-2021-may-report-dprk/">https://www.eaaflyway.net/2021/05/26/wmbd-2021-may-report-dprk/</a></p> <p>WWD news:  <a href="https://kcna.watch/newstream/1612170085-534949552/wetlands-and-water/">https://kcna.watch/newstream/1612170085-534949552/wetlands-and-water/</a></p> <p><a href="https://kcna.watch/newstream/1580605286-340045974/preservation-of-wetlands-and-biodiversity-in-dprk/">https://kcna.watch/newstream/1580605286-340045974/preservation-of-wetlands-and-biodiversity-in-dprk/</a></p>	Since joining Ramsar and EAAFP in 2018, DPRK raised awareness and promote World Wetlands Day and World Migratory Bird Day.
Regional (for YS)	2018	Announcement of a new funding opportunity for the YS.	<a href="https://www.wetlands.org/news/arcadia-fund-helps-us-support-restoration-management-critical-habitats-migratory-waterbirds-yellow-sea/">https://www.wetlands.org/news/arcadia-fund-helps-us-support-restoration-management-critical-habitats-migratory-waterbirds-yellow-sea/</a>	A new grant from Arcadia supports Wetlands International to work with local governments and other stakeholders along the coast of the Yellow Sea in PRC.
DPRK	2019	Swan Goose Festival	<a href="https://www.eaaflyway.net/2019/1/05/first-swan-goose-festival-in-dprk/">https://www.eaaflyway.net/2019/1/05/first-swan-goose-festival-in-dprk/</a>	Highlighting the celebration of the Swan Goose in DPRK.

Country	Year	Activity	Coverage address	Brief details
			<a href="https://www.dpr-korea-celebrating-world-migratory-bird-day/">dpr-korea-celebrating-world-migratory-bird-day/</a>	
International (for YS)	2021	Mr. Felix Glenk from Hanns Seidel Foundation (HSF) Korea, the co-organizer of the symposium shared Democratic People's Republic of Korea (DPRK) and developments for wetland conservation, acknowledging the strong efforts made in DPRK.	<a href="https://www.eaaflyway.net/2021/10/27/11th-intecol-new-zealand/">https://www.eaaflyway.net/2021/10/27/11th-intecol-new-zealand/</a>	Mr. Glenk shared some key activities in DPRK, such as video production that brought wetland conservation into context for the general audience; the video can be viewed here. Hence, DPRK's close cooperation with HSF and Ministry of Land and Environment Protection since 2015 has led to important outcomes such as international, national, and local workshops, biodiversity surveys in potential Ramsar Sites, and study tours. Moreover, it has enhanced networks, awareness raising and produced a national wetlands inventory including more than 50 important wetlands in DPRK. He shared that trust-building through environment cooperation, integrated international environmental networks, and exchange in transboundary issues in the Korean peninsula is key to continue this momentum in wise use wetland conservation in DPRK.

Country	Year	Activity	Coverage address	Brief details
International (for YS)	2021	Yellow Sea Working Group	<a href="https://www.eaaflyway.net/2019/11/19/3rd-meeting-of-the-trilateral-yellow-sea-working-group-held-in-shinan-ro-korea/">https://www.eaaflyway.net/2019/11/19/3rd-meeting-of-the-trilateral-yellow-sea-working-group-held-in-shinan-ro-korea/</a>  <a href="https://www.eaaflyway.net/2021/06/15/yellow-sea-joint-inventory-webinar/">https://www.eaaflyway.net/2021/06/15/yellow-sea-joint-inventory-webinar/</a>  <a href="https://www.eaaflyway.net/2019/12/12/2019-shinan-international-symposium-on-conservation-strategy-for-migratory-birds-and-their-habitats-in-the-yellow-sea/">https://www.eaaflyway.net/2019/12/12/2019-shinan-international-symposium-on-conservation-strategy-for-migratory-birds-and-their-habitats-in-the-yellow-sea/</a>	Highlights from Working Groups who are collaborating to strengthen the Yellow Sea.
International (for YS)	2015		<a href="https://www.eaaflyway.net/asian-waterbird-census/">https://www.eaaflyway.net/asian-waterbird-census/</a>	AWC has collected the data in YS, working for CSR currently
International (for YS)	2021	Highlights from the World Conservation Congress	<a href="https://www.iucncongress2020.org/programme/official-programme/session-43376">https://www.iucncongress2020.org/programme/official-programme/session-43376</a>  <a href="https://www.eaaflyway.net/2016/09/09/report-from-the-wcc-in-hawaii/">https://www.eaaflyway.net/2016/09/09/report-from-the-wcc-in-hawaii/</a>	Representation of the Yellow Sea at the IUCN World Conservation Congress in Hawaii (2016) and France (2021).

Country	Year	Activity	Coverage address	Brief details
DPRK	2021	5 Day Joint Bird Survey	<a href="https://www.eaaflyway.net/2021/10/27/11th-intecol-new-zealand/">https://www.eaaflyway.net/2021/10/27/11th-intecol-new-zealand/</a>	After the 1st Swan Goose Festival at Mundok Migratory Bird Reserve on 13th October 2019, a 5-day joint bird survey by researchers from MoLEP, Academy of Science of Korea, Hanns Seidel Foundation, WWF-Hong Kong and Hong Kong Bird Watching Society was conducted to cover three significant wetlands in the DPRK (14th to 18th October 2019). It included long road trips from Pyongyang to Wonsan where we stayed for two nights to facilitate visits to Lake Tongjong and Lagoon Chona (14th and 15th October) and Kumya Migratory Bird Reserve (15th and 16th October). Back to Pyongyang, two more morning surveys were carried out at Mundok Migratory Bird Reserve (17th and 18th October). We recorded 105 species in total with several species of global conservation concern.
DPRK	2020	Bird news by Dr. Bernhard Seliger and Felix Glenk of Hanns Seidel Foundation Korea together with Spike Millington, CEO of EAAFP, Raphael Glemet and Angela Joehl Cardena of IUCN and the very supportive	<a href="http://www.birdskoreablog.org/?p=19566">http://www.birdskoreablog.org/?p=19566</a>	Mundok migratory bird reserve in Mundok county, Pyongan-bukdo, is one of the most important migratory bird reserves in the DPRK. Here, sometimes more than 40.000 Swan Goose stay and numerous other threatened water birds. Summer is a relatively calm period, but still a number of interesting observations could be made. Unexpectedly, a single Swan Goose swam along the river, presumably either sick or too exhausted to travel further. Though bird identification was

Country	Year	Activity	Coverage address	Brief details
		team of Mr. Kim and Ms. Pang of the Ministry of Land and Environment Planning and local researcher of the State Academy of Sciences, Mr. Yu.		difficult without a scope, more than 200 Terek Sandpiper, plus smaller numbers of Far Eastern Curlew, Whimbrel, Common Greenshank and Grey Plover were seen, as well as Mongolian and Black-tailed Gulls. Also somewhat unexpected was the presence of at least twelve Common Shelducks, usually winter visitors. In the reed fields, several Yellow Bittern and at least one Von Schrenck's Bittern, Chinese Pond Heron, Common Moorhen and Watercock were seen (one on a close range in a rice paddy). Also, there were dozens of Oriental Reed Warblers, many of them mimicking the sounds of redshanks and other waders.
DPRK	2022	EAAFP Partner Hanns Seidel Foundation Korea (HSF Korea) attended the 6th Rason International Trade Exhibition in the Democratic People's Republic of Korea (DPRK), 8-11 August 2016.	<a href="https://www.eaaflyway.net/2016/09/06/hsf-attends-6th-rason-international-trade-exhibition-in-dprk/">https://www.eaaflyway.net/2016/09/06/hsf-attends-6th-rason-international-trade-exhibition-in-dprk/</a>	The DPRK has many important habitats for migratory waterbirds such as Scaly-sided Merganser, Swan Goose and Black-faced Spoonbill. The EAAFP Secretariat worked together with HSF Korea in developing CEPA materials for the poster session last year and updating the materials this year. Hanns Seidel Foundation Korea specifically supports and promotes cooperation and exchange on the Korean Peninsula. While the DPRK is often isolated from the international community for internal and external reasons, this isolation can be a severe threat when it concerns environmental issues that need transnational

Country	Year	Activity	Coverage address	Brief details
				efforts. Hanns Seidel Foundation conducts different activities to tackle this threat.
DPRK	2021	In April 2009 the Korean Natural Environment Conservation Fund (NCUK) and PūkoROKoro Miranda Naturalists' Trust (PMNT) completed a joint survey of shorebirds at Mundok, 80 km northwest of Pyongyang.	<a href="https://www.eaaflyway.net/2015/06/25/joint-shorebird-survey-of-the-onchon-county-coast-of-dprk-2/">https://www.eaaflyway.net/2015/06/25/joint-shorebird-survey-of-the-onchon-county-coast-of-dprk-2/</a>	This was the first known survey of birds using tidal areas of the Yellow Sea of DPRK. In 2014 a joint agreement was signed in Pyongyang between NCUK and PMNT to expand this work with a series of shorebird surveys along the Yellow Sea coast, starting in 2015.
ROK	2021	Highlights of bird monitoring work in ROK.	<a href="https://www.eaaflyway.net/2021/04/30/national-monitoring-of-black-faced-spoonbills-and-study-on-their-habitats-in-the-republic-of-korea-2020/">https://www.eaaflyway.net/2021/04/30/national-monitoring-of-black-faced-spoonbills-and-study-on-their-habitats-in-the-republic-of-korea-2020/</a>  <a href="https://www.eaaflyway.net/2021/1">https://www.eaaflyway.net/2021/1</a>	Study about breeding status, population, national distribution, and habitat use by satellite tracking were conducted for the first time, for the conservation of endangered Black-faced Spoonbills in the Republic of Korea. Max. 3,327 birds were observed by the simultaneous monitoring on



Country	Year	Activity	Coverage address	Brief details
			<a href="#">2/09/the-far-eastern-curlew-national-survey-in-ro-korea-2021/</a>	September, 2020 from 20 main sites including 7 sites of Incheon in Korea
ROK	2020 - 2021	First Workshop on Yellow Sea Ecosystem Conservation	<a href="https://www.eaaflyway.net/2016/02/05/workshop-on-yellow-sea-ecosystem-conservation-held-in-the-republic-of-korea/">https://www.eaaflyway.net/2016/02/05/workshop-on-yellow-sea-ecosystem-conservation-held-in-the-republic-of-korea/</a>	The first workshop on Yellow Sea Ecosystem Conservation was held at the National Marine Biodiversity Institute of Korea in Seocheon on 15 December 2015. It was organised by the Ministry of Ocean and Fisheries (MOF), the Ornithological Society of Korea, Korea Marine Environment Management Corporation (KOEM), Korea Institute of Environmental Ecology and Green Wetland Education. The workshop brought together key Korean partners, central and local governments, technical experts, NGOs and citizens closely engaged in intertidal mudflat conservation, especially for endangered species of coastal and marine wildlife such as Spoon-billed Sandpiper, Bar-tailed Godwit and Black-faced Spoonbill.
PRC	2016	Regional dialogue on the conservation management of the intertidal wetlands of	<a href="https://www.eaaflyway.net/2018/02/13/regional-dialogue-on-the-conservation-management-of-the-">https://www.eaaflyway.net/2018/02/13/regional-dialogue-on-the-conservation-management-of-the-</a>	Story highlighting the Regional dialogue on the conservation management of the intertidal wetlands of the Yellow and Bohai Seas.

Country	Year	Activity	Coverage address	Brief details
		the Yellow and Bohai Seas	<a href="#">intertidal-wetlands-of-the-yellow-and-bohai-seas/</a>	

Source: EAAFP

## **Appendix 8. Compendium of Yancheng Outcome Documents: extracts from 2017, 2018, 2019, 2020**

### **2020 Yellow and Bohai Sea Coastal Wetlands Symposium (main decisions) (Y20)**

1. It is essential to have a long-term plan for the WH property to provide direction to its conservation management, benefit to the local people, and to embed it within a broader Yellow Sea context. This is even more critical during the expansion of the Yellow and Bohai Sea property to tie together its different elements across the tidal areas of the Yellow and Bohai Seas. Such a site management plan is vital to mitigate, via habitat restoration and creation, loss of waterbird habitat, from causes such as hydrological changes, sea-level rise, invasive alien *Spartina cord grass*, and aquaculture ponds.

2. A network of multi-functional feeding and roost sites should be maintained and created at regular intervals along the Jiangsu coast to provide both safe and disturbance-free roost areas and foraging sites for waterbirds in the face of changes in intertidal mudflat feeding areas. These need to be managed by a range of established evidence-based tools, including site-related management planning, zoning of different activities to different parts of the wetland, and creation of disturbance-free refuges. Ultimately, good solutions will come from ensuring bird-friendly human activity.

3. Strengthening and developing well-coordinated multi-disciplinary research programmes on, and year-round monitoring of, waterbirds and wetlands in Yancheng and other important Yellow Sea sites is critically important to provide the evidence-base for planning, demonstrating, and adapting successful management and restoration actions. Monitoring should be harmonized with, and build on existing expertise and networks of government, NGOs, and experts. Development of a Yellow Sea collaborative platform is recommended for sharing and reporting monitoring data and other information to help meet World Heritage, Ramsar, and EAAF Partnership obligations.

4. The Wadden Sea case study clearly demonstrated the importance of stakeholder involvement to fully develop World Heritage site's potential while respecting and improving its Outstanding Universal Value.

There is great potential for wetland centres in Yancheng to implement education, ecological tourism, and monitoring in order to significantly stimulate ongoing development of these along the flyway. They can demonstrate and refine sustainable development principles, balance creating world class visitor experiences with sensitively managing reserves for wildlife, and become models for wetland conservation and solutions.

#### **4. Global Coastal Forum**

The forum could *inter alia* provide a platform for global coastal conservation that collates information to identify priorities and ensure the implementation of evidence-based coastal ecosystem conservation management and restoration including to deliver nature-based solutions. It could use horizon scanning to identify forthcoming opportunities and challenges, use solution scanning to identify possible options, use evidence-based conservation combined with best theory and local experience to provide guidance on interventions, and use well designed and automated monitoring systems to ensure learning and improvement in practice.

### **2019 Yancheng Consensus (Y19) Sep 30th 2019 Yancheng, PRC**

1. It is proposed to establish a City Alliance along the EAAF to strengthen the close ties and cooperation of cities along the flyway, promote the protection of wetlands and migratory birds and the sustainable development of cities.

2. Recent decisions of the Ramsar Convention on Wetlands, the Convention on Migratory Species and the Convention on Biological Diversity call for the establishment of a “Global Coastal Forum”. It was suggested that Yancheng can play a key role in this, for example by offering to the Ramsar Secretariat the possibility of setting up an office in Yancheng to support the Forum and build Yancheng into an international wetland city with first-class international standards.
3. It is recommended to develop Yancheng Yellow Sea Wetland into a world-class demonstration of sustainable coastal wetland management achieving objectives for the integrity of the coastal wetland ecosystem and the wellbeing of migratory birds, biodiversity and local communities by carrying out evidence-based ecological assessment and restoration, especially to strengthen a) the comprehensive management of the invasive alien species *Spartina alterniflora* and b) the protection, management and creation of high-tide roost sites for waterbirds close to their main intertidal feeding sites.
4. The World Heritage sites can also become a showcase for the research on and conservation and management of “Working Coastal Wetlands” to achieve conservation of birds and sustainable development of local communities, focussing on the intertidal zone for shellfish fisheries and on the artificial wetlands above the sea wall, including salt ponds and aquaculture.
5. It is suggested that a flexible, dynamic and responsive eco-tourism development team should be set up to plan a high-quality eco-tourism conservation management and sustainable development strategy, according to clear criteria, focusing on the well-being and cultural needs of the people, as well as the protection and health of wetlands and the birds that depend on them. This should be for the Phase I property in relation to the entire serial World Heritage site, building on international experience and establishing world-class standards. At its core should be a focus on strengthening and maintaining public participation and ecological education.

## **Yancheng 2018 (Y18)**

Recommendation 1- Further develop the management plan for the Yancheng, Dongsha and Tiaozini ecosystem and ensure that it becomes a demonstration site exemplary to other national, Yellow Sea, and global sites;

Recommendation 2 - Operationalise the Yancheng Institute, with a local to global remit, to ensure management of Yancheng and other coastal sites is undertaken with proper evidence-based monitoring of what works, including leading to a national/Yellow Sea *Spartina* eradication programme, assessing the potential impact of wind turbines on birds population and developing guidance on management of ‘working coastal wetlands’ including shellfisheries, salt pans, aquaculture and rice paddies, for birds and people;

Recommendation 3 - Develop a Sustainable Development Plan for Yancheng that can act as a model for elsewhere on the China coast including the accreditation of Yancheng as a wetlands city, sustainable Working Coastal Wetlands and an eco-tourism trail around the Yellow Sea coast;

Recommendation 4 - Develop Yancheng and China as global leaders in coastal wetland conservation including by i) contributing to flyway conservation and the UNESCO Marine World Heritage programme; ii) triggering dialogues with ROK on the coordinated management

of proposed WH sites; iii) playing a leading role in establishment of the proposed CBD/Ramsar/CMS Global 'Caring for Coasts' Forum and iv) support and lead site twinning initiatives with neighbouring countries;

Recommendation 5 – Further engage in international events and showcase Yellow Sea coastal wetland conservation success at the EAAFP MOP in December 2018; the second meeting of the Yellow Sea Transboundary Working Group in early 2019; the World Conservation Congress in June 2020 and the Convention for Biological Diversity COP15 in Beijing in October 2020;

Recommendation 6 – Develop, implement and/or strengthen awareness and outreach programmes at local, national and international levels, emphasizing the importance of the Yellow Sea intertidal wetlands and associated ecosystem services, with a particular focus on policy makers and developers at local, provincial and national levels, using existing Communication, Education, Participation and Awareness (CEPA) programmes.

Recommendation 7 – Explore the better integration of Yancheng wetlands and other coastal wetlands in National and Global Blue carbon strategies and identify the contribution of those ecosystems in terms of resilience and mitigation to climate change at local, national and global levels including, but not limited to, their contribution to the National Determined Contributions under the Paris agreement;

## **2017 Yancheng Declaration (Y17)**

1. The nomination of the intertidal wetlands of the Yellow and Bohai seas for inscription on the World Heritage List.

The Yellow and Bohai seas region is home to Asia's largest and most important intertidal wetlands, which form a crucial link in the East Asian-Australasian Flyway and one of the world's largest ranges of migratory water birds. Its significant ecological value forms a scientific basis for the region's nomination as a World Heritage site in recognition of its potential Outstanding Universal Value (OUV). During the Yancheng Symposium, for the first time, representatives of the relevant national governments joined forces to further explore the various options for a World Heritage nomination, and for enhanced international coordination on the conservation and management of intertidal wetlands in the region. Representatives advocate relevant countries and regions to formulate species conservation mechanisms and standards in line with the provisions of the World Heritage Convention.

2. The joint conservation of the region's intertidal wetlands ecosystems and the wildlife that depends on them.

This is a critical issue for the governments responsible for managing and sustaining wetlands in the region. In the past 50 years the wetland area of the Yellow and Bohai seas have declined by about 66 percent. The wetlands ecosystems and the migratory birds that depend upon them have been significantly impacted by the reclamation of land for development. Some iconic water-bird species are Endangered or even Critically Endangered according to the IUCN Red List of threatened species. Other critical factors that have impacted on the wetland's

ecological health include water pollution due to the overuse of fertilizers and insecticides in agriculture, and the reclamation of land for industrial and urban development, etc. In addition, climate change-driven extreme weather events present a significant long-term threat to these wetlands. Given these conditions it is recommended that a more systematic monitoring program is developed, and one that is linked to an adaptive management framework to support early intervention to prevent further adverse environmental consequences, and to help restore the wetland's resilience. Such monitoring would also be required for World Natural Heritage declaration. Representatives advocate to establish Yancheng Coastal Wetland Research Institute to further research on scientific protection of wetlands, and a yearly International Symposium undertaken to review conservation issues and achievements.

3. The joint realization of Sustainable Development in line with the standards of the World Heritage Convention. This section focused in particular on the wetlands areas of the Yellow and Bohai seas in terms of the potential economic and social development opportunities associated with World Natural Heritage nomination. It is recognized internationally that the World Heritage brand is associated with a rapid growth in tourism. However, the critical issue is how this is managed to prevent new tourism infrastructure having negative impacts on the wetland. With a focus on both migratory water-birds and Père David's deer, the region could also become a significant attraction for international nature-based tourism, drawn to the region both for its wildlife but also its healthy environment and the quality of the ecotourism experience itself. For this reason, representatives advocate to adopt an 'ecotourism' standard in line with IUCN guidelines, where experiencing the wetland's environment and the wildlife it supports are an integral part of the tourism experience.

Finally, participants of the Yancheng Symposium share a common vision for the sustainable development of the wetlands of the Yellow and Bohai Seas and their nomination for inscription on the World Heritage List.



INTERNATIONAL UNION  
FOR CONSERVATION OF NATURE

ASIA REGIONAL OFFICE  
63 Sukhumvit Soi 39  
Klongtan - Nua, Wattana  
10110 Bangkok, Thailand  
Tel +66 (2) 662 4029  
Fax +66 (2) 662 4387  
[www.iucn.org/asia](http://www.iucn.org/asia)

