Coastal Reclamation and Impact to Critical Coastal Habitats of Yellow Sea Large Marine Ecosystem

China

Report document for

Natural Resource Specialist to Assess Coastal Reclamation and Impact to Critical Coastal Habitats of Yellow Sea Large Marine Ecosystem

Sponsored by

UNOPS Individual Contractor Agreement: 0207829-P68276-L0-00

Prepared by

Yu Liu

Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences

Contributors

Shaoxia Xia

Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing;

Zhongqi Zhang

School of Geography, Geomatics and Planning, Jiangsu Normal University, Xuzhou, Jiangsu Province;

Liang Zhao

College of Earth Sciences, Chengdu University of Technology, Chengdu, Sichuan Province;

Li Xu

School of Geography, Geomatics and Planning, Jiangsu Normal University, Xuzhou, Jiangsu Province.

Preface

Yellow Sea Large Marine Ecosystem is critical for biodiversity conservation, peculiarly the migratory water birds (Ma et al. 2014, Szabo et al. 2016). Every year, millions of various birds migrate into and out of the coastal wetland of Yellow Sea Large Marine Ecosystems (Cui et al. 2016). Wetlands in this region are called “fueling station”. In the past decades, due the large demands on more land to support the economy development derived by booming economy in east Asia, large areas of coastal lines, mushes, sandy beaches are reclaimed. This situation is not a good news for the huge population of migratory birds on EAAF, and diverse fish and benthos living in this valuable habitats.

For this reason, a UNOPS individual Contractor Agreement (0207829-P68276-L0-00) was signed to evaluate the status of biodiversity in the Chinese part of YSLME, to reveal the gaps of protection for this precious and seriously threatened ecosystem.

Table of Content

1 Distribution of critical habitats in coastal wetland in Yellow Sea, China 1
1.1 Habitats and their biodiversity status in YS China 1
1.2 Critical bird habitats in the YS, China 2
1.3 Critical habitats of shellfish and invertebrate in the YS, China 5
2 Land use changes and wetlands reclamation in YSLME 8
2.1 Land use/cover pattern and change in the Past three decades 8
2.2 Costal line pattern and change in Yellow Sea coast zone of China 11
3 Threats of critical habitats in Yellow sea coast 18
3.1 Habitat area reduction 18
3.2 Alternating land-ocean hydrological connectivity 20
3.3 Pollution 20
3.4 Ecosystem productivity 22
4 Conservation status and gaps 23
4.1 Conservation gaps on critical shorebird habitats 23
4.2 Conservation gaps on critical shellfish habitats 27
5 Proposals on management measures 28
5.1 Protect the opportunities for new habitat emerging 30
5.2 Keep the rolling relief 30
5.3 Encourage synergy utilization of marsh and reclaimed coastal marsh .. 31
5.4 Design habitat network for conservation as a resolution for fragmented landscape 31
References 32
Appendix 35

List of figures and maps

Figure 1 Critical bird habitat sites identified followed criterion 2, 5 and 6 of Ramsar Convention......3
Figure 2 Number of critical habitatsin provinces of Yellow Sea......3
Figure 3 Critical habituated sites for Waders, Stork and Crane, Laridae, and Anatidae......4
Figure 4 Critical habitats for Shellfish in the Yellow Sea, China (Jin et al. 2013, Yang et al. 2013, Zhang et al. 2014)......7
Figure 5 land use change from 1980 to 2015 in the coastal zone......9
Figure 6 Ecosystem composition in the coastal zone......8
Figure 7 Composition of ecosystems in typical areas in the China coastal zone of YSLME......10
Figure 8 Satellite imageries used in coastal lines extraction......12
Figure 9 Status of coastal line in China part of YSLE in 2009 (Left) and 2016 (right)......13
Figure 10 Coastal reclamation and restoration in YSLE of China during 2009-2016......13
Figure 11 Status of coastal line reclamation in Liaodong Bay......14
Figure 12 Status of coastal line reclamation in Bohai Bay......15
Figure 13 Status of coastal line reclamation in Laizhou Bay......15
Figure 14 Status of coastal line reclamation in Rudong......16
Figure 15 Summary of coastal line length of province in YSLE, China......17
Figure 16 Typical fragmented shorebird habitats on mud flat of Bohai bay......18
Figure 17 Disturbances to shorebirds habituating on Yellow Sea coastal mudflats......19
Figure 18 Planned reclamation (2011-2020) announced by administrations in Yellow Sea (Wang et al. 2014)......20

Figure 19 Water quality and sedimentation pollutant level of oceans neighboring pollutant emission outlets (State Oceanic Administration, PRC. 2018). The higher the grade, the worse the quality. Water with a grade over IV is considered as seriously polluted water..21
Figure 20 Typical non-point sources of pollution of coastal wetlands and oceans...21
Figure 21 Changes of biomass of benthic macrofauna in Laizhou Bay, Southern Jiangsu province 22
Figure 22 Composition of biomass of benthic macrofauna in Southern Jiangsu province...22
Figure 23 Spatial intersection of critical bird habitats and conservation areas in the forms of ecological redlines and national natural reserves 24
Figure 24 Spatial intersection between critical bird habitat of four shorebird categories and conservation areas in the forms of ecological redlines and national natural reserves 26
Figure 25 Spatial overly between protected areas, in the form of ecological redline and national natural reserves, and critical habitats for shellfish, fish and shrimp..27
Figure 26 Spatial conflicts between habitats protection and reclamation actions 28
Figure 27 Sediment flow cut off due to sluices construction (left and middle) and long continuous dikes (right) during reclamation 30
Figure 28 Difference in relief profile between natural marsh flat (left) and marsh flats beyond dikes (right) 31

List of tables

Table 1 Characteristics of bird records derived from bird watching and literatures 1

Table 2 Critical habitat for shellfish in YS and the indicator species（Li & Li, 2008）.. 6

Table 3 Classification systems of coastal lines 11

Table 4 Summary of acreage changes of coastal wetlands in Yellow Sea, China 14

Table 5 Goals for natural coastal line protection assigned to provinces in the coastal region (State Oceanic Administration, PRC, 2017) 18

Table 6 Statistics for critical bird habitats covered by announced redlines 25

Table 7 Summary of the status protection for the habitats of four shorebird categories 25

Table 8 Status of habitat protection for shellfish in Yellow Sea, China 27

Table 10 Key achievement indicators given by the Outline of National Territory Planning of China (2016-2030) 29

1 Distribution of critical habitats in coastal wetland in Yellow Sea, China

1.1 Habitats and their biodiversity status in YS China

Bird records derived from the bird watching and literatures. Bird watching records obtained from the China Bird Report① contributes most of the records. A script was developed to download the released records from the pages of the website. Besides, investigation data from reports such as "*The Asian Waterbird Census 2008-2015: results of coordinated counts in Asia and Australasia*" (Mundkur et al., 2017), "*Yellow Sea – Bohai region coordinated waterbird survey 2016. Summary report*." (Chen, et al, 2016), et al, were integrated with records from China Bird Report. Totally, more than 80000 records of 268 bird species appeared in the Yellow Sea coastal wetlands from June 2001 to April 2018 were collected (Table 1, Appendix A). Each records covers species common name, scientific name, date of watching, place name, geographical coordinate and bird counts. The two data sources, i.e., bird watching records download from the website and data mined from literatures are different in data quality. Usually, the latter data source is more qualified, though the geographical area it covers is relative narrow, a very few sites were investigated. After a careful check of the data from the two sources, they are integrated together to generate a bird records data base.

Table 1 Characteristics of bird records derived from bird watching and literatures

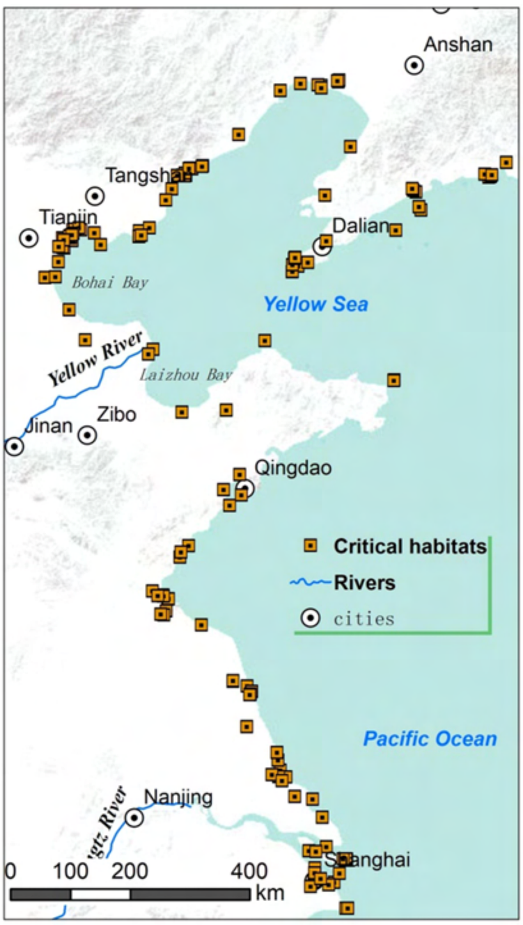
Total records	Species covered	Duration
87344	268	2001.6~2018.7

Organisms such as shellfish and sea grass living in the intertidal marsh and terrestrial wetlands near the sea shore are critical for a qualified habitat of birds, which are flag indicator species in coastal wetlands. Therefore, information on the organisms other than birds that relies on coastal wetlands also collected. However,

①websites of China Bird Report: http://www.birdreport.cn/?AspxAutoDetectCookieSupport=1 most of this information is pick out from published papers.

1.2 Critical bird habitats in the YS, China

Critical habitats are identified followed the criteria for Ramasar wetlands and standards of important bird habitat areas provided by Birdlife International. Maps of critical habitats in YS coastal wetlands were developed for all birds habituate the coastal wetlands of Yellow Sea, and for waders, Stork and Crane, Laridae and Antidae (Figure 1 and Figure 3). By using the bird records, critical sites in the Chinese coastal wetlands of Yellow Sea were identified. As showed by Figure 1, wetlands in the estuary of Yangtz River, coastal area of Jiangsu Province, Jiaozhou Bay near Qingdao, southern part of Laizhou bay, from middle to northern part of Bohai bay, estuary of Liao River, and coastal areas neighboring Dalian are highly critical for providing qualified habitats for water birds (Figure 1).



Ramsar Convention Criterion for critical bird habitat identification:

Criterion 2: if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 5: if it regularly supports 20,000 or more water birds.

Criterion 6 if it regularly supports 1% of the individuals in a population of one species or subspecies of water birds.

Figure 1 Critical bird habitat sites identified followed criterion 2, 5 and 6 of Ramsar Convention

Totally, 137 sites are identified as critical followed the criteria given in Figure 1. Their geographical coordinate are given in Appendix B. Of these critical habitats, the largest number is in Liaoning, followed by Jiangsu (Figure 2). Both of the two provinces have a long coastal line, especially the mud flat coast line. The number of critical sites in Tinajin is rather large as considering the short shoreline length and small acreage of coastal wetlands (Figure 2). Due to the great proportion of rocky and sandy shoreline, Shangdong has a small number of critical sites, though its shoreline is very long.

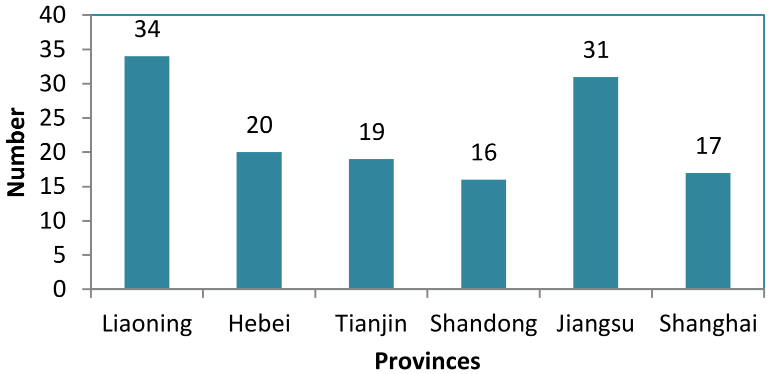


Figure 2 Number of critical habitatsin provinces of Yellow Sea

Waders, Stork and Crane, Laridae, and Anatidae are dominant categories of migratory birds rely on Yellow Sea coastal wetlands. Critical habituated sites for Waders, Stork and Crane, Laridae, and Anatidae are given separately in Figure 3. For all categories, Liaohe estuary, coastal mudflat of Tianjin and Jiangsu are important habitats (Figure 3).

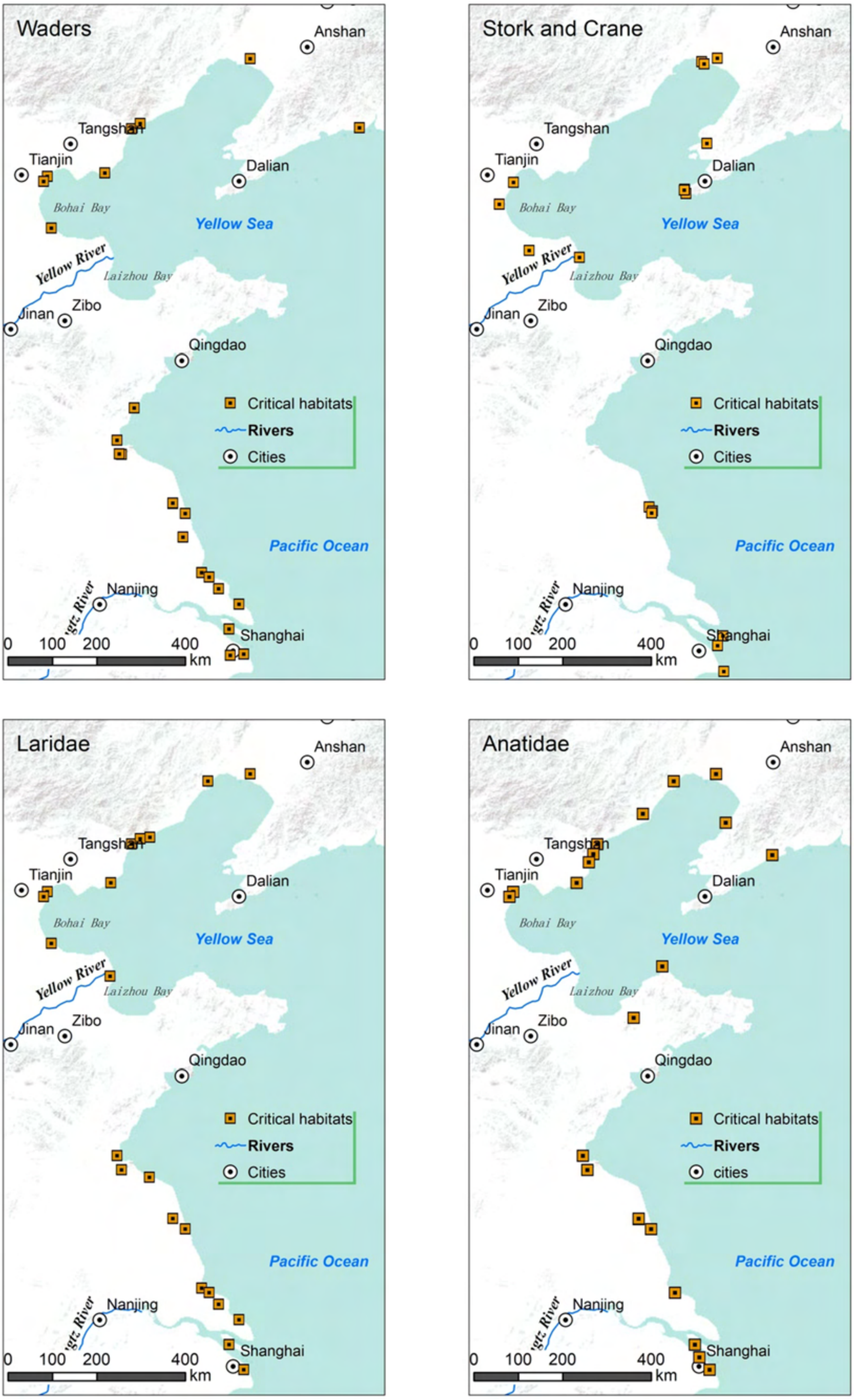


Figure 3 Critical habituated sites for Waders, Stork and Crane, Laridae, and Anatidae

1.3 Critical habitats of shellfish and invertebrate in the YS, China

Tidal mush in Yellow Sea is owns most of the plain coast of China. The gentle topography and vast tidal mush make this region the qualified habitats for various fish, shellfish, invertebrates and benthos, which are valuable foods for migratory birds stop over the coastal wetlands (Murray et al. 2015, Szabo et al. 2016, Yong et al. 2017). This is one of the reasons the coastal wetlands in Yellow Sea are the “fueling station” on EAAF(Chen et al. 2015, Murray et al. 2015). Critical habitats for shell fish in the coastal intertidal wetlands were identified by literature review. Following principals are relied on in determining critical habitats: (1) clear arguments and investigation-based; (2) at least one important species habituated; (3) a description of boundary is best and not a necessary. According to Li&Li（2008）, Jin(2008) and Ma（2008）, 12 critical habitat zones for shellfish located in the Yellow Sea, which were argued by WWF in 2005 in video meeting on the Yellow Sea Biodiversity. 14 shellfish were selected as indicator species.Li & Li, 2008）. This list of critical habitat zones covered Dalian, Huludao, Qinhuangdao, Tanggu, Changdao, Yantai, Weihai, Rushan, Haiyang, Qingdao, Rizhao and Lianyungang (Table 2).

Table 2 Critical habitat for shellfish in YS and the indicator species（Li & Li, 2008）

English name	Latin Name	Critical habitat zones											
		Lianyungang	Rizhao	Qingdao	Haiyang	Rushan	Weihai	Yantai	Changdao	Tanggu	Qinghuangdao	Huludao	Dalian
Mussel (贻贝)	*Mytilus edulis*	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Mactra (蛤蜊)	*Mactra veneriformis*	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Short Necked Clam (杂色蛤)	*Ruditapes philippinarum*	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Meretrix (文蛤)	*Meretrixmeretrix*	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Mactra chinensis (中国蛤蜊)	*Mactra chinensis*	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Chlamys ferreri (栉孔扇贝)	*Chlamys farreri*		♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Subcrenata (毛蚶)	*Scapharca subcrenata*		♠	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Burnt-end Ark (魁蚶)	*Scapharca broughtonii*			♠		♠	♠						♠
Ostrea gigas (长牡蛎)	*Crassostrea gigas*			♠	♠	♠	♠	♠	♠	♠	♠	♠	♠
Razor clam (缢蛏)	*Sinonovacula constricta*	♠	♠	♠	♠	♠	♠	♠		♠	♠	♠	♠
Abalone (鲍鱼)	Haliotidae species	♠		♠				♠	♠			♠	♠
Pinnapectinate (栉江珧)	*Atrina pectinata*			♠				♠	♠				♠
Cockle (鸟蛤)	*Fulvia mutica*			♠		♠		♠			♠		
Chinese cyclina (青蛤)	*Cyclina sinensis*	♠	♠	♠	♠	♠		♠	♠		♠		♠

Due to the vast tidal mudflat and great productivity, coast areas in Yellow River delta, Bohaibay, Laizhou bay and Jiangsu province are suitable habitats for many benthic species including shellfish (Leng et al. 2013, Zhang et al. 2014), and are their critical habitats (Li & Li, 2008) (Figure 4).

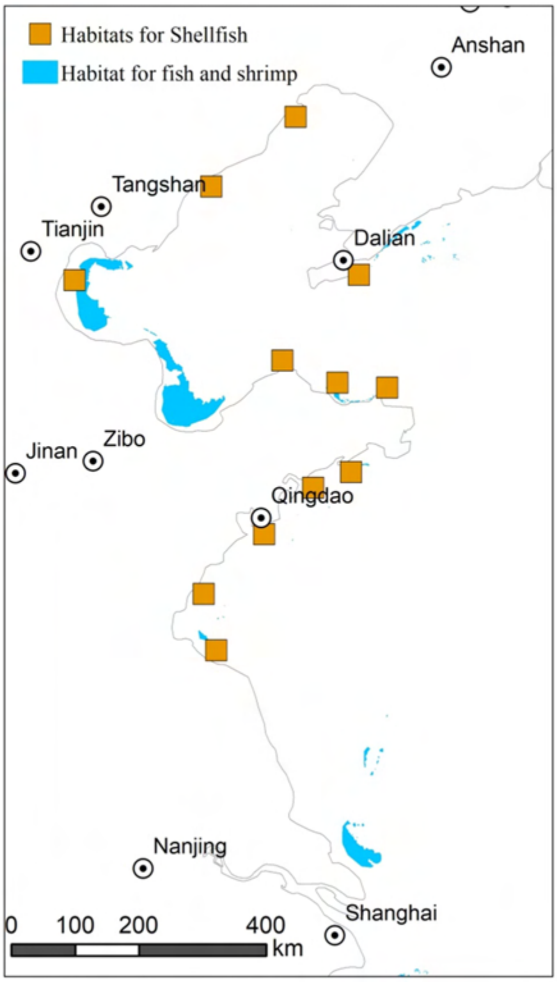


Figure 4 Critical habitats for Shellfish in the Yellow Sea, China (Jin et al. 2013, Yang et al. 2013, Zhang et al. 2014)

The biomass of benthos reflects the capacity of intertidal mudflat to support species in higher trophic level. Tidal mushes in southern Jiangsu province are one of the critical habitats for shellfish and invertebrates (Figure 21), and thus the critical habitats for birds feed on mush flat benthos (Figure 1).

2 Land use changes and wetlands reclamation in YSLME

2.1 Land use/cover pattern and change in the Past three decades

The ecosystem pattern in the Yellow Sea coastal area experienced a rapid change in the past 2 decades. The dynamic of ecosystem pattern of 1980-2015 within the 20 km buffer zone of coastal line in 2009 were mapped. As being given by Figure 6, farmland is the dominant ecosystem, especially in the southern part. Its acreage continuously increases before 2005, and slightly decline thereafter. Sandy and bare coastal area (categorized into desert ecosystem for convenience of identification from satellite imageries), which is a typical natural ecosystem in this area, shrunk continuously in this period. Though a lot of the intertidal areas have been reclaimed for fish farming, the land used by which also classified as wetland, the total acreage of wetland was on the downslope. Settlement ecosystem, which mainly refer to land occupied by buildings, roads, ports in this region, is up to 22% of the total area in 2015. However, in 1980, it occupied 12% of the total area. Generally, in the Yellow Sea coastal zone, natural land, especially the sandy area and the wetlands rapidly shrunk since 1980s.

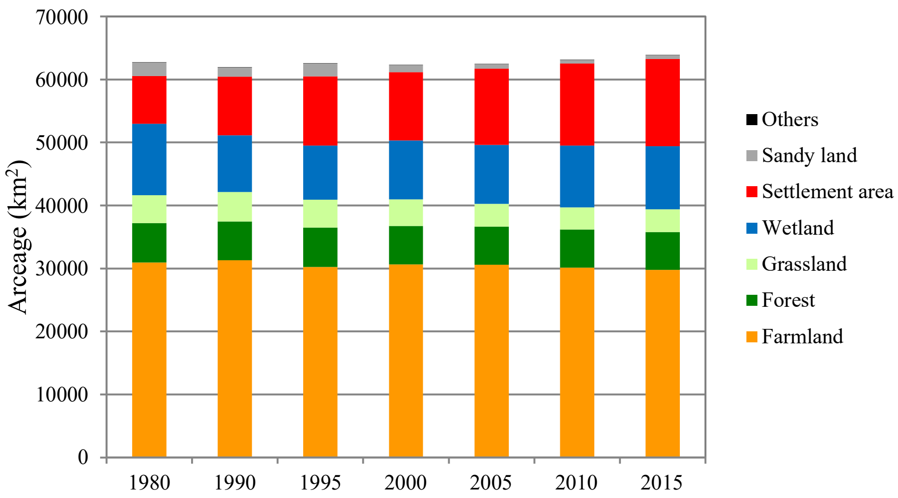


Figure 5 Ecosystem composition in the coastal zone

The Chinese coastal region of Yellow Sea has experienced a stage of large magnitude reclamation in the in the past decades. This change process reflects the reshape of the ecosystem composition through coastal wetland reclamation and ocean filling. The speed of ecosystem pattern change in the Yellow Sea coastal zone in China varies dramatically from the northern to the southern. It can be found in Figure 7 that the total acreages of ecosystems in all of the five typical regions are on the rise, accompanied by a shrinking of natural sandy areas and wetlands. Ecosystem acreage composition of Liaodong Bay coastal region in the northern of Yellow Sea is dominated by farmland ecosystem and forest ecosystem, which is determined by greater portion of the mountainous area and the rocky coastal line. The proportion of farmland ecosystem and forest ecosystem is rather stable. And the acreage of settlement ecosystem rose continuously.

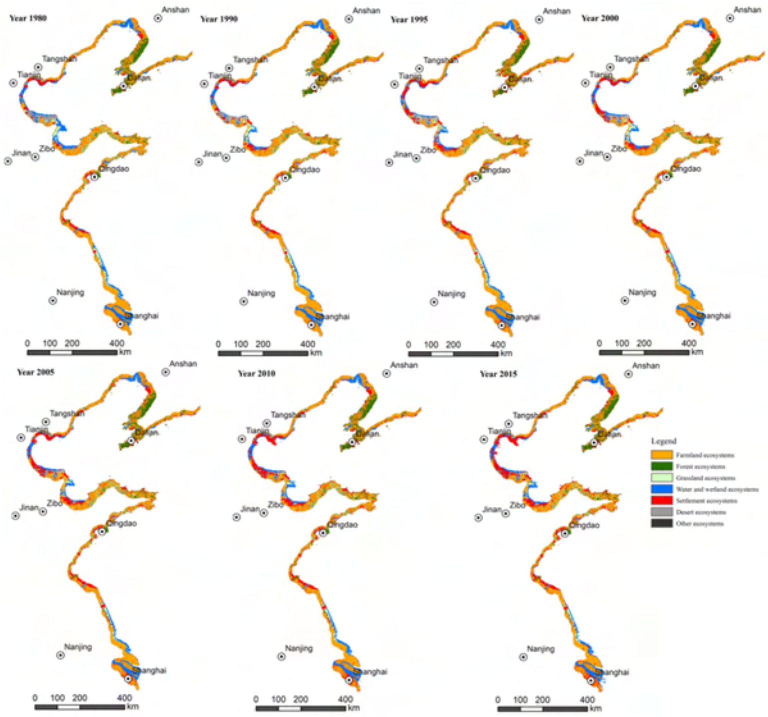
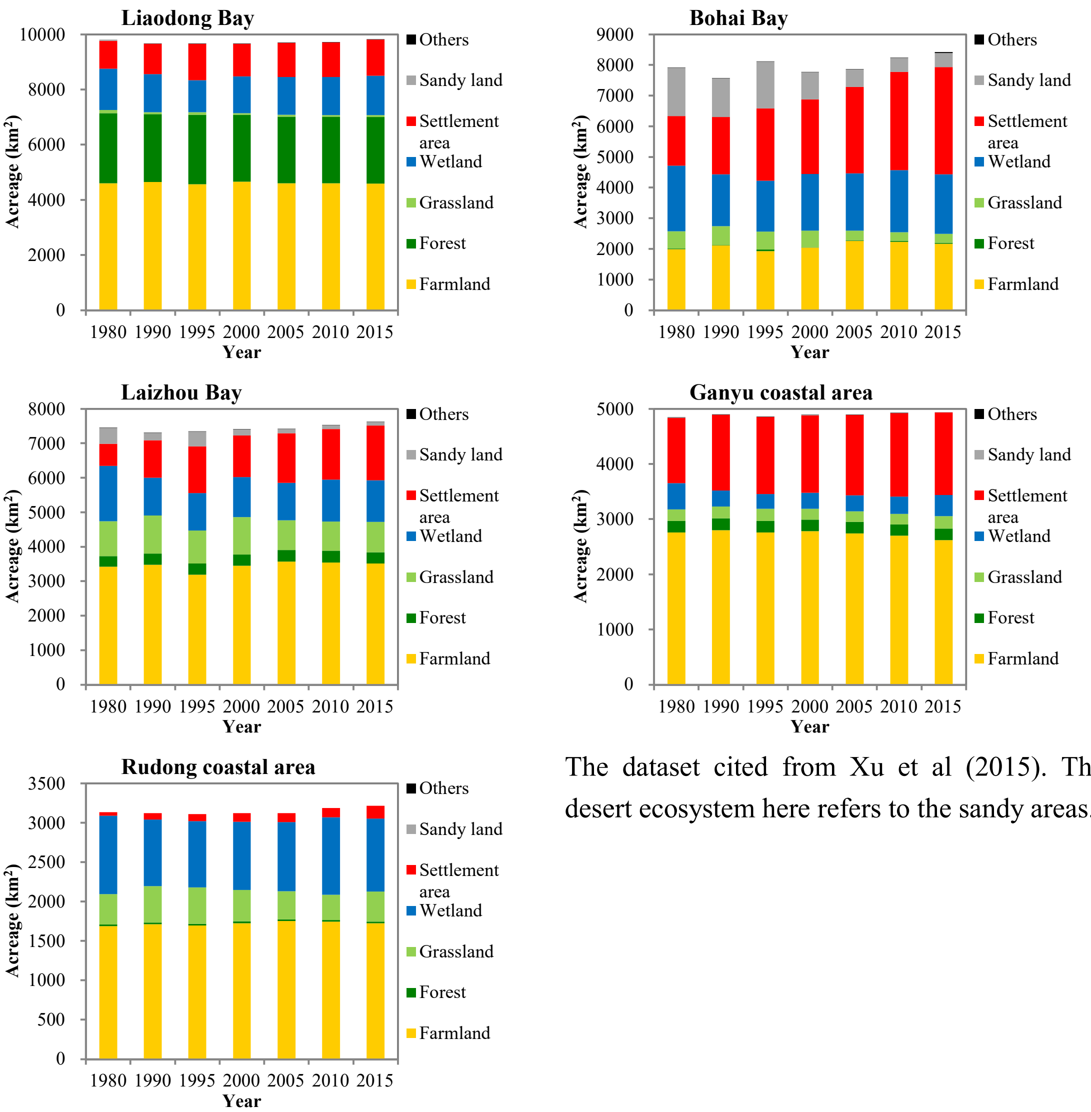


Figure 6 land use change from 1980 to 2015 in the coastal zone

Wetlands acreage also slightly increased. In Bohai Bay, the sandy coastal area, an important form of natural coastal ecosystem in this region, shrunk dramatically from 1980to 2005; while a fast expansion of settlement ecosystem occurred in this period and continued to 2015. The settlement ecosystem is the dominant ecosystem since 2000 in Bohai Bay coastal region. Coastal area of Ganyu in the northern Jiangsu Province has a similar situation with Bohai Bay: the muddy wetlands, flat relief and rapidly expanding settlement ecosystem along the coastal lines. Though there is no mega city in Laizhou Bay coast, the real estates developed quickly. The speed of terrestrial area growing pushed by human interventions though ocean filling and dike construction is rather high. Sandy areas, which dominated natural coast in 1980s, shrunk to small and highly fragmentized patches (Figure 5 and Figure 7). The coastal area in Rudong is of critical for stopover of many globally vulnerable and endangered migratory bird species (Studds et al. 2017, Yong et al. 2017). The wide and flat muddy coastal wetlands enable Rudong coastal wetlands a suitable habitat. However, as showed by Figure 5 and Figure 7, reclamation, mainly in the form of dike construction, is rather huge in this area. In contrast to Laizhou Bay, many factories are built on the reclaimed land, which is of great threat to the quality of nearby habitats. Generally, the changes in ecosystem acreage composition showed a loss in natural ecosystems.



The dataset cited from Xu et al (2015). The desert ecosystem here refers to the sandy areas.

Figure 7 Composition of ecosystems in typical areas in the China coastal zone of YSLME

2.2 Costal line pattern and change in Yellow Sea coast zone of China

2.2.1 Coastal line extraction

By using the satellite imageries of Landsat TM and OLI/TIRS of 2009 and 2016, the coastal lines of the Yellow Sea were extracted and classified followed the categories systems given in Table 3. The imagery resolution is 30 m. Coastal lines of the Yellow Sea are classified into three types: Natural coast line, Reclaimed coastal lines, and coastal lines under reclamation. Each contains several sub-types.

Table 3 Classification systems of coastal lines

Types	Sub-types	Descriptions
Natural	Rocky	Rocky coastal lines without infrastructures
	Sandy	Sandy coast lines.
	Mud	Mud flat coast lines.
	Vegetated	Coastal lines occupied by mangroves, coral reefs and grass species.
Reclaimed	Spur dike and jetty	Strips built for preventing damages of waves, and extend into sea.
	Port	Coastal lines of ports.
	Fish farming	Coastal lines of fish farming, with levees separate the sea and ponds.
	Salt farm	Coastal lines of salt farms.
	Road	Coastal lines with roads built on.
	Tidal levee	Levees used to separate sea and lands, and functioning in prevent impact of waves
Reclaiming		Coastal lines with constructing infrastructures, building levees extended into sea

25 sciences of imageries were collected for year 2009, and 23 for 2016. All the coastal lines of the Yellow Sea of China are covered, as well as North Korea, South Korea. However, in this report, we focus on the coast of China in the Yellow Sea Region.

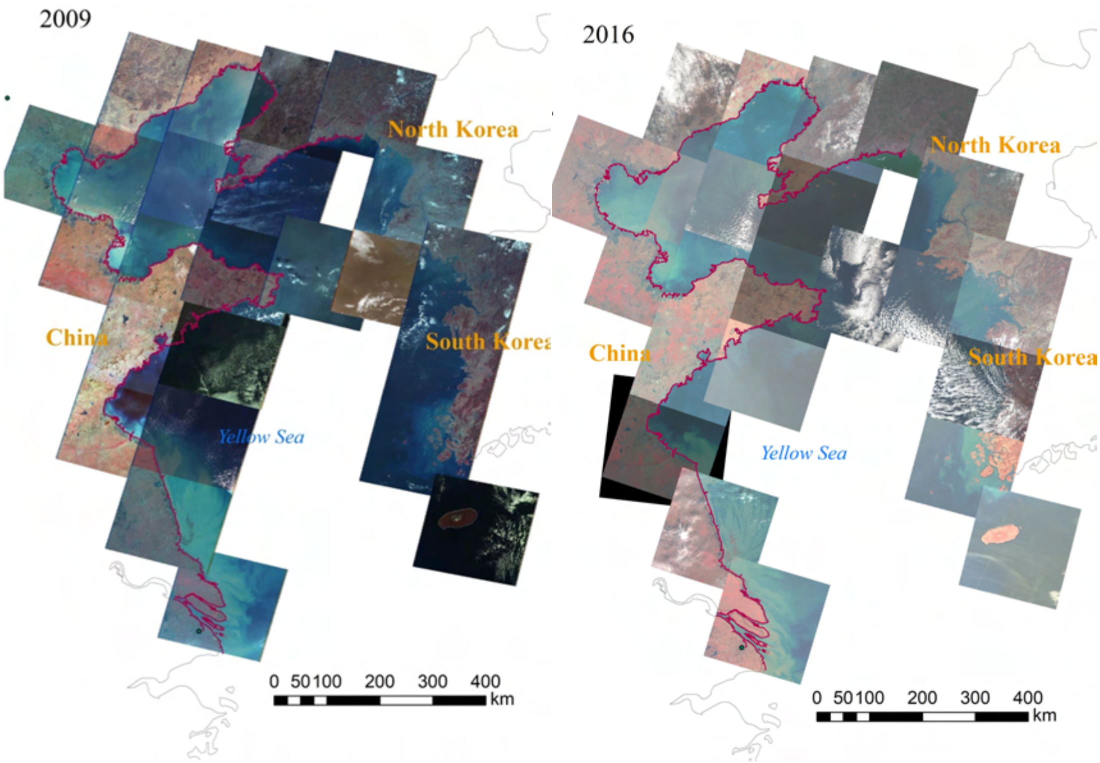


Figure 8 Satellite imageries used in coastal lines extraction

2.2.2 Change of coastal lines

In Yellow Sea coast zone of China, the coastal lines experienced a dramatic change during 2009 and 2016. This change features in expanding of reclaimed and reclaiming coastal lines and shrink of natural coastal lines, accompanied by a few restored natural segments and some newly generated natural lines (Figure 9). The investigation of Chinese coastal line Yellow Sea based on satellite remote sensing imageries showed that the natural coastal line occupies 29.9% of the total coastal line length in 2009. This ratio declined to 21.7% in 2016 (Figure 9).

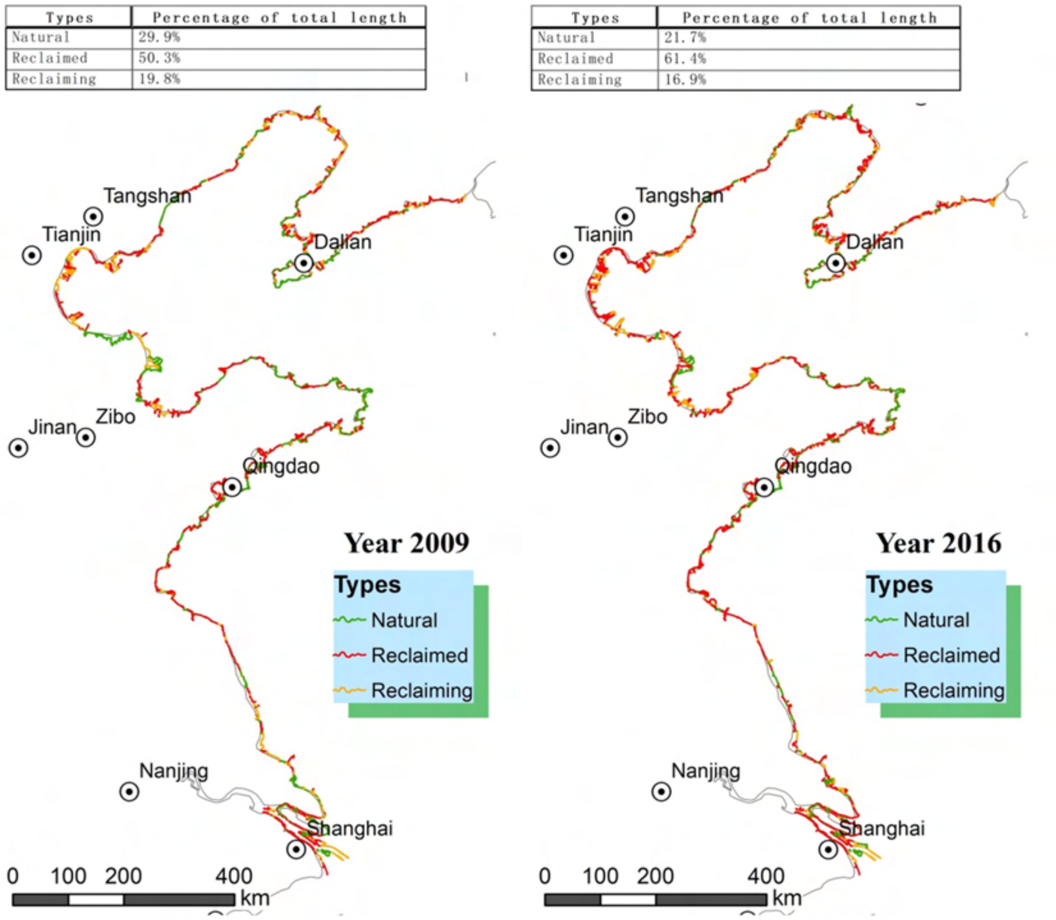


Figure 9 Status of coastal line in China part of YSLE in 2009 (Left) and 2016 (right)

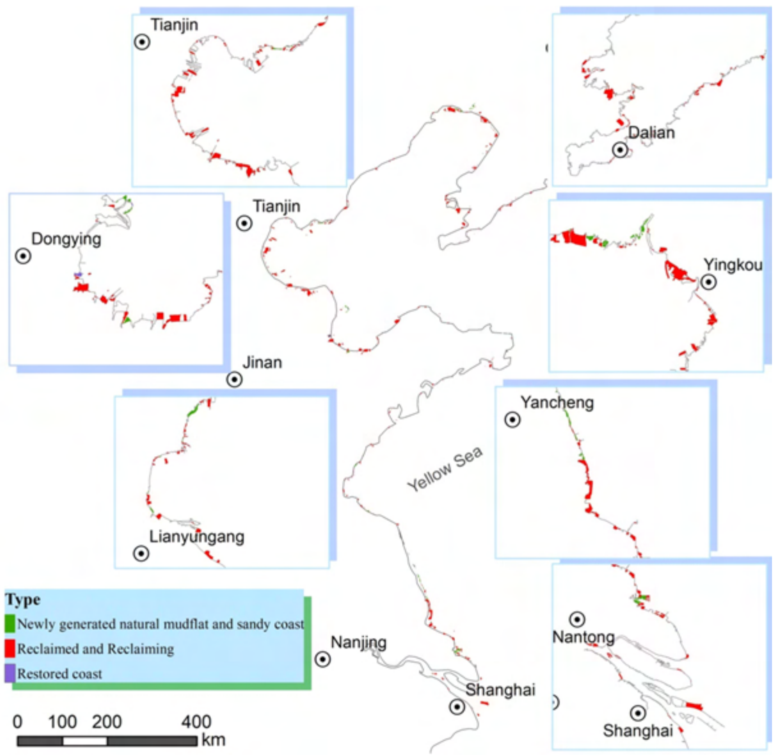


Figure 10 Coastal reclamation and restoration in YSLE of China during 2009-2016

Table 4 Summary of acreage changes of coastal wetlands in Yellow Sea, China

Type	Number of plots	Area (km^2)
Restored coast	27	18.93
Reclaimed and Reclaiming	560	1583.07
Newly generated natural mudflat and sandy coast	66	153.89

Coastal lines in Liaodong Bay, Bohai Bay, Laizhou Bay, and Jiangsu province are fiercely reshaped by anthropogenic activities. In Liaodong Bay, the natural coastal occupies 28.1% in 2009, and 27.75% in 2016. For Bohai Bay, which covers coastal line of Tianjin and part of Hebei, the ratio of natural coastal lines just occupies 19.45% in 2009, and 15.23% in 2016. Actually, as illustrated by Figure 12, there almost is no natural coastal line left in Tianjin. Ports, roads, residential buildings and fish farming dikes reshaped the coastal lines.

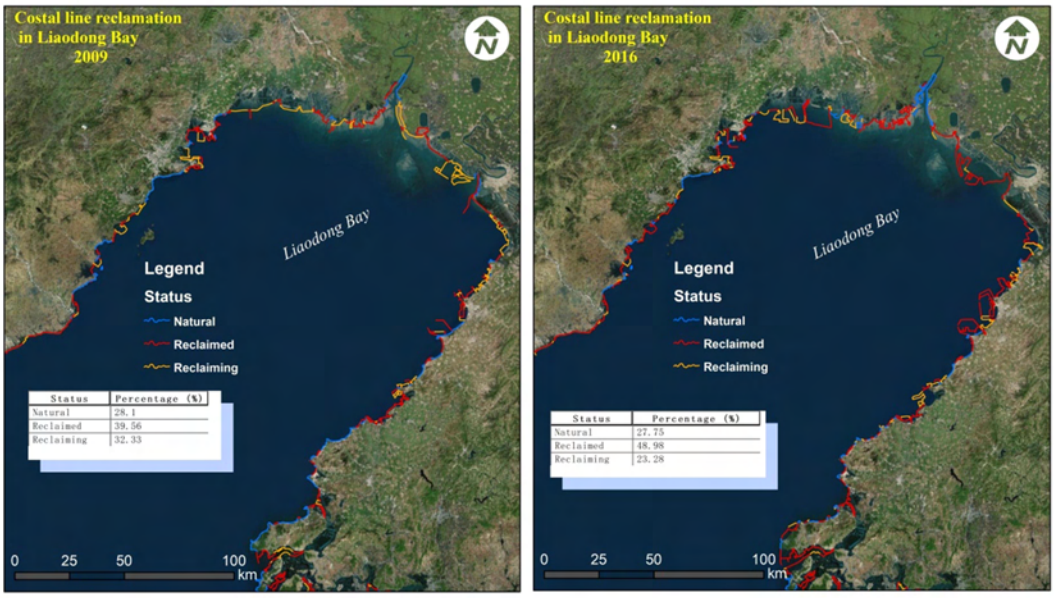


Figure 11 Status of coastal line reclamation in Liaodong Bay

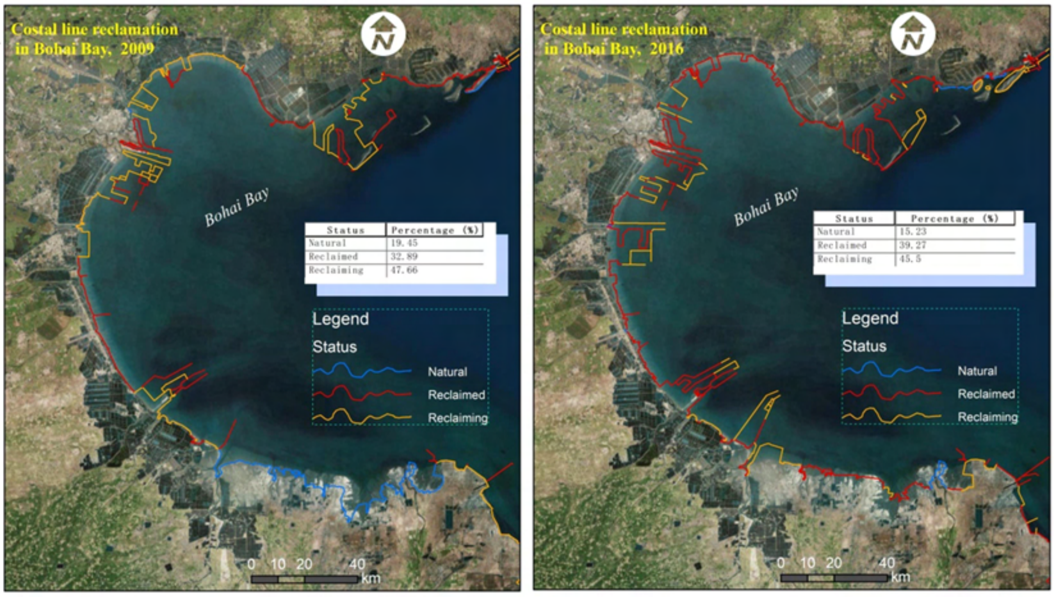


Figure 12 Status of coastal line reclamation in Bohai Bay

Situation of natural coastal ratio in the Laizhou Bay also is the similar, though with a little different causes. Expanding of fish farming, salt and oil exploitation, rapid development of coastal real estates are dominant driving forces for the loss of natural coastal lines. In 2009, the ratio of natural coastal lines is 10.84%. This figure went down to 8.44% in 2016. Several magnitude ocean filling project are on the way in the eastern Laizhou Bay, most of them are real estate projects.

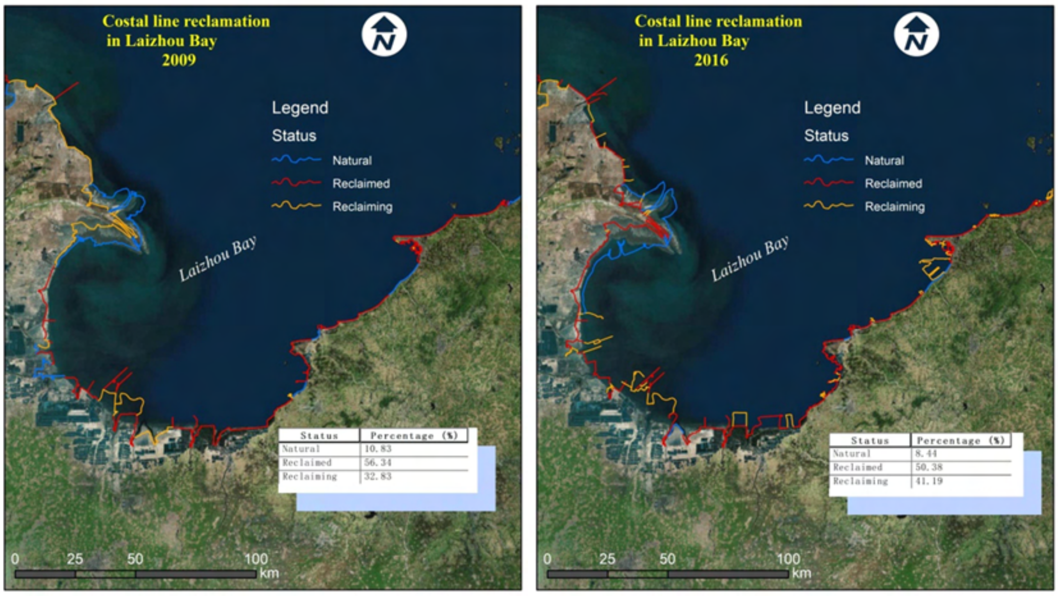


Figure 13 Status of coastal line reclamation in Laizhou Bay

Coastal lines Jiangsu Province, such as those in Rudong, are of critical importance for migratory water bird, shellfish and invertebrates benthos in their life history, as showed in 1.2 and 1.3. Due to the flat relief, thick mud and the great demand of land generated by strong economy development in Jiangsu Province, the magnitude of marsh flat reclamation is very huge in the past decades. In 2009, the ratio of natural coastal line near Rudong is 33.24%. However, it fell to 27.99% in 2016. It is must be keep in mind is that most of the so called natural coastal lines are new emerged due to the large amount of terrestrial silt sediment flow. Unfortunately, the sediment flows are vastly cut off due to the construction of long continuous dikes along the sea shore, and sluices for channel control. In some segments, erosion of coastal line is more apparent due to ceased supplement of sediment from terrestrial ecosystems.

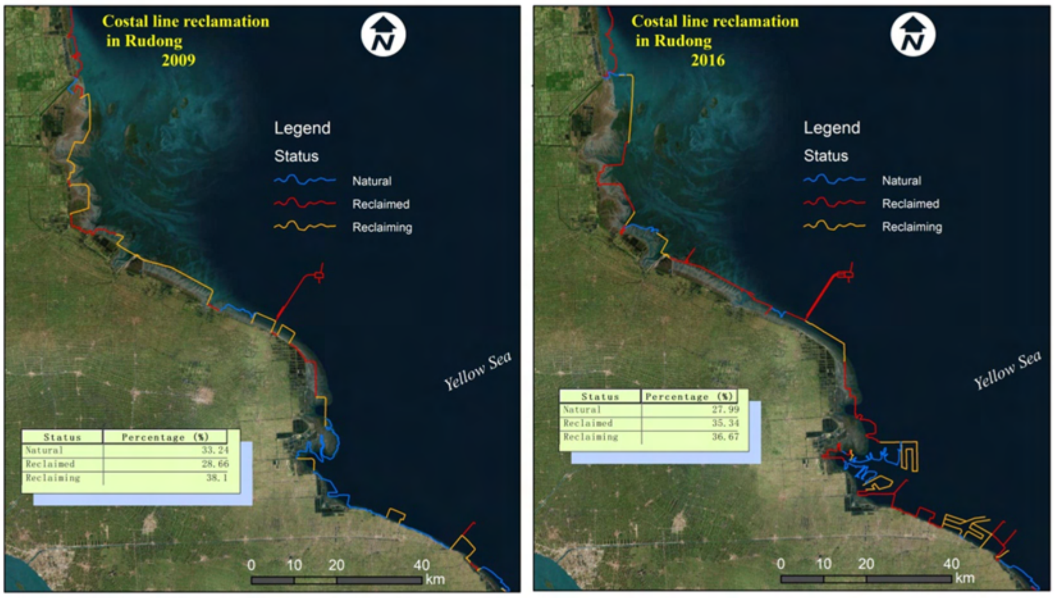


Figure 14 Status of coastal line reclamation in Rudong

However, furthermore reclamations are on the way of execution or planning according to the files announced by the governments from central to provinces. The natural coastal line is more and more fragmentized. However, as reported by many scientific literatures, species need habitat patches, peculiarly the threshold of core area of patches, with an area larger than a threshold. For bird species, an alarming distance of habituated patches from settlement areas and noisy infrastructures are necessary. Along with the further fragmentation of natural coastal lines, the suitable coastal wetlands also are more fragmented and reduced. Besides, dredged sediment hydraulic filling, which relocates ocean sediment from locations with a certain distance from the seashore, greatly disturbs the benthos of the intertidal wetlands and reshape its rolling relief with deep channels. This will further reduce the space of suitable habitats in addition to reclaim wetlands for industries.

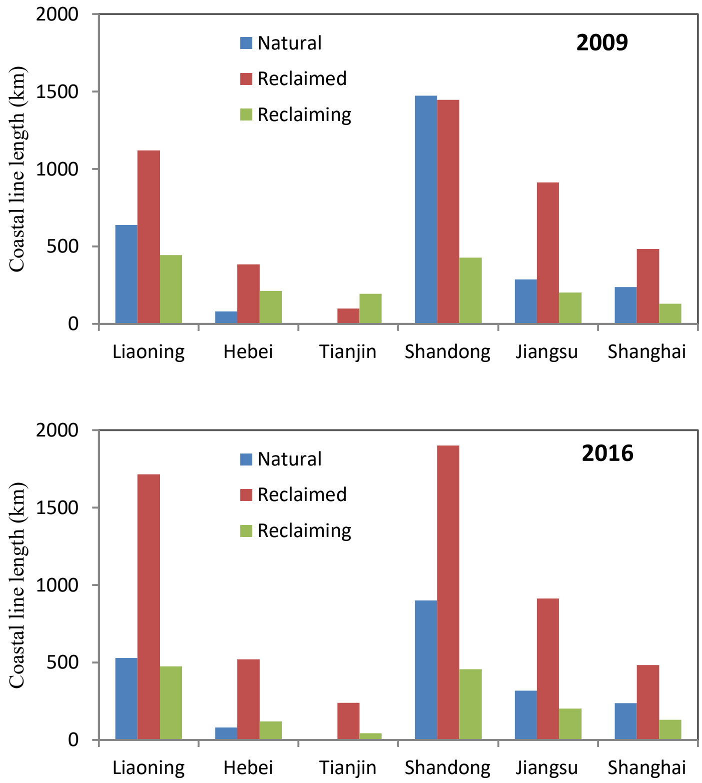


Figure 15 Summary of coastal line length of province in YSLE, China

Conservation of the natural coastal line is of critical importance for healthy intertidal wetland habitat protection. According to "*the Measures for the Protection and Utilization of Coastlines*"(海岸线保护与利用管理办法) issued by the State Oceanic Administration, PRC., in 2020, the natural coastal line must occupy 35% or more of the total length of coastal line, not including the coastal line of islands. Provinces in the coastal region of Yellow Sea were given a specific goal for natural coastal line protection, as list in Table 5. As showed in Table 5, in most of the provinces, the ratio of natural coastal line in 2016 is lower than the goals of 2020. Therefore, it seems it's surely impossible for provinces in this region to achieve the goal given in Table 5 without a large magnitude restoration of coastal lines, such as the action taken in fish farming marsh flat in Liaohe estuary.

Table 5 Goals for natural coastal line protection assigned to provinces in the coastal region (State Oceanic Administration, PRC, 2017)

Province	Liaoning	Hebei	Tianjin	Shangdong	Jiangsu	Shanghai
Goal for ratio of natural coastal line	≥ 35%	≥35%	≥5%	≥40%	≥35%	12%
Ratio of natural coastal line in 2016*	19.49%	11.15%	0.86%	27.66%	22.16%	28.04%

*Natural coastal lines in this report just cover the coastal line of continent

3 Threats of critical habitats in Yellow sea coast

3.1 Habitat area reduction

Loss of intertidal mudflats in around the Yellow Sea is considered to be the primary driver of declines for migratory shore birds using the East Asian-Australasian Flyway (EAAF) (Que et al. 2015, Studds et al. 2017, Szabo et al. 2016). Due to the shrink of spaces for a stopover, wintering or breeding, shorebirds are gathering into small fragmented habitats on the coastal wetlands (Figure 16). Various disturbances occurred and occurring are common on or neighbor the coastal wetland habitats (Figure 17). They have to suffer disturbances from neighbor land uses, and a deteriorated physical quality of habitats (Hua et al. 2015, Que et al. 2015, Studds et al. 2017).

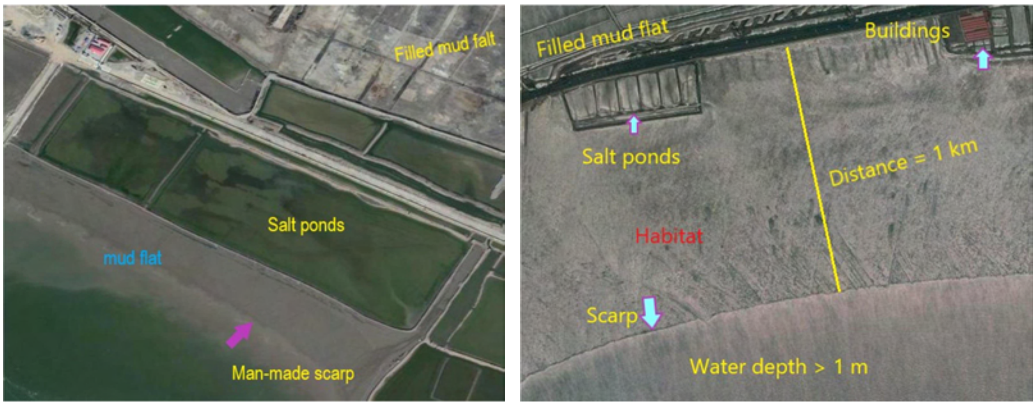


Figure 16 Typical fragmented shorebird habitats on mud flat of Bohai bay

(a) Oil exploration infrastructures in Yellow River delta

(b) mud flat reclamation activities in Jiangsu mudflat

(c) Wind farm near Yanchen

(d) Disturbed mudflat topography in Ganyu

Figure 17 Disturbances to shorebirds habituating on Yellow Sea coastal mudflats

As results of the shrinking habitat area and deteriorated habitats quality, the survival of the shorebirds is at a crucial situation (Hua et al. 2015). The population size of waders on EAAF are experiencing a shrinking process (Studds et al. 2017). Using 20 years of continent-wide citizen science data, Studds et al. (2017) argued that population trends of ten shorebird taxa that refuel on Yellow Sea tidal mudflats declined, and seven of the taxa declined at rates of up to 8% per year. The shrink of mudflats in the Yellow Sea is considered as the main reason for the decline of population of migratory shorebird on EAAF (Studds et al. 2017). In a modeling approach, Que et al. (2015) illustrated a low nest survival of breeding for Kentish plover populations in Bohai Bay, China.

However, the reclamation will go on for the economy development and livelihood of local residents. Provinces of Yellow Sea planned a huge reclamation area in past years (Figure 18). Though a file from State Council paused the reclamation in 2018, and a more strictly rules are provided for coastal wetlands reclamation, the long-term trend of more intensive cultivation of coastal wetlands is evitable for the benefit of the whole country. It is sure we will face a more fragmented and narrow habitats for wild species rely on Yellow Sea coast wetlands and neighboring oceans.

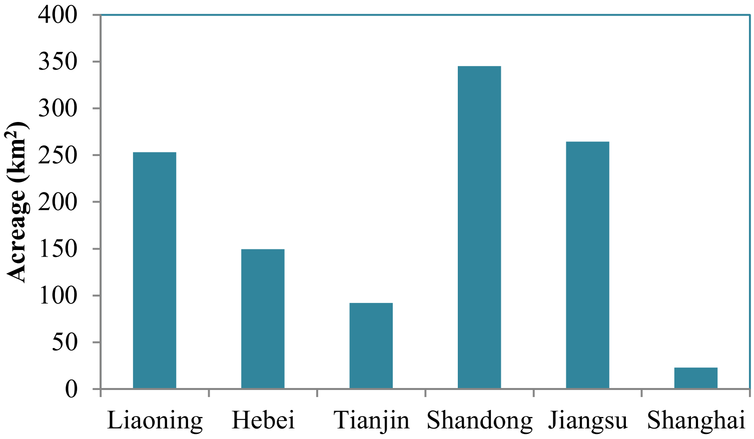


Figure 18 Planned reclamation (2011-2020) announced by administrations in Yellow Sea (Wang et al. 2014)

3.2 Alternating land-ocean hydrological connectivity

Hydrological connectivity are critical for the sustainability coastal wetlands (Chen and Chen 2002). However, reclamations alternate the land-ocean hydrological connectivity in many ways. Construct of sluices and dams on rivers and streams is one of the common ways. They impeded the sediment and hydrological connectivity between inland water bodies and the sea, and thus indirectly limited the supply of some nutrients that is critical for the sustainability of coastal ecosystems, and most importantly, the sediment flow to maintain mudflats and fresh water for mitigated salinity.

3.3 Pollution

According to *Bulletin of China Marine Ecological Environment Status* (State Oceanic Administration, PRC., 2018), water quality of 55 monitored rivers flow into oceans are still serious polluted, rivers with water quality below Grade V occupied 44%, 42%, and 36% of all rivers in low water period, wet season, and normal flow season, respectively. Water grades over IV are of greatest proportion from 2013 to

2017 for oceans of China (Figure 19). This implies a serious situation of pollution on coastal wetlands. What's more, pollutant emission in Yellow Sea region is the greatest in China, especially heavy metals (Meng et al. 2008).

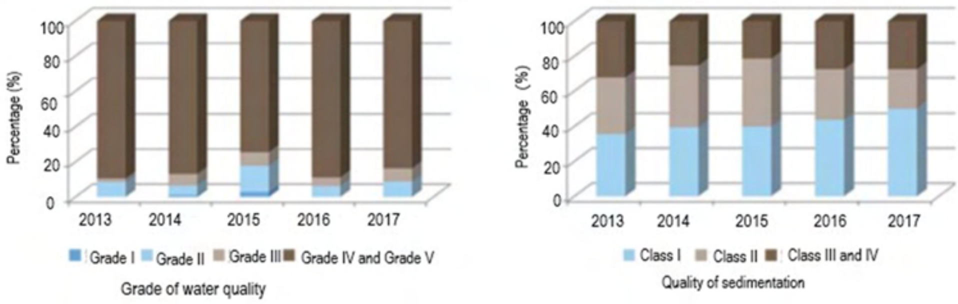


Figure 19 Water quality and sedimentation pollutant level of oceans neighboring pollutant emission outlets (State Oceanic Administration, PRC. 2018). The higher the grade, the worse the quality. Water with a grade over IV is considered as seriously polluted water.

The land reclaimed in Yellow Sea coastal wetlands are used for ports, factories, fish farming, and residential areas (Figure 6,Figure 5). They are important contributors for the pollutant emission to the coastal wetlands and oceans. Due to the distributed nature, non-point pollutions derived from fish farming, residential areas, roads, and farmlands seriously threaten the ecosystem health and coastal habitat quality.

Figure 20 Typical non-point sources of pollution of coastal wetlands and oceans

As a result of the loss of natural mud flats and vegetated coast, the capacity of coastal ecosystems to adopt and mitigate the huge amount of pollutions is weakened. The species living in coastal ecosystems may face serious environmental situations shaped by increased pollutant flux.

3.4 Ecosystem productivity

As refer to the productivity on mud flats without reclamations, the productivity did not show a trend of decline. According to Zhang et al. (2014), the biomass of benthic macrofauna in intertidal mudflats in southern Jiangsu province increased from 1980s to 2010s. Mollusk contributed most of the biomass from 1980s to 2010s, with a decline in the proportion (Figure 22). In Laizhou Bay, the biomass of benthic macrofauna experienced unimodal change from 2006 to 2010 (Leng et al. 2013).

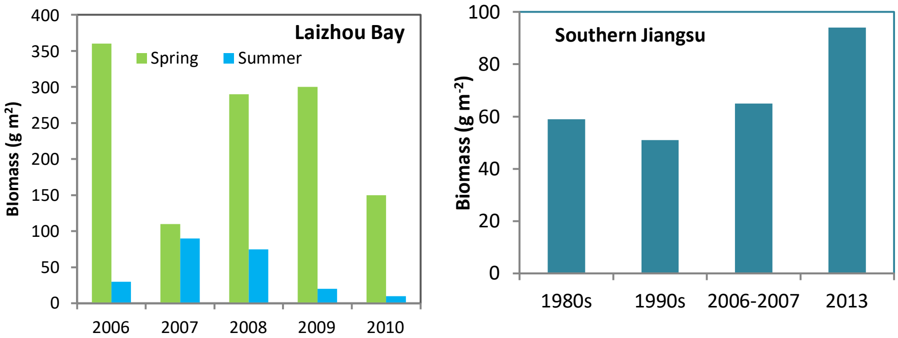


Figure 21 Changes of biomass of benthic macrofauna in Laizhou Bay, Southern Jiangsu province

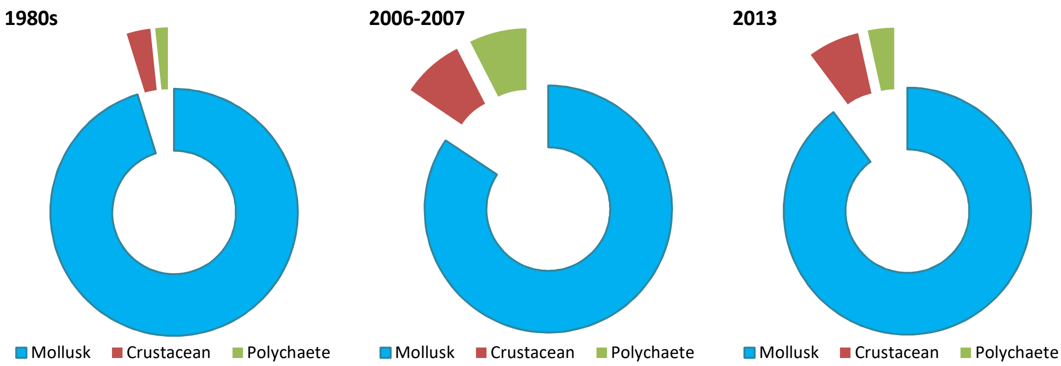


Figure 22 Composition of biomass of benthic macrofauna in Southern Jiangsu province

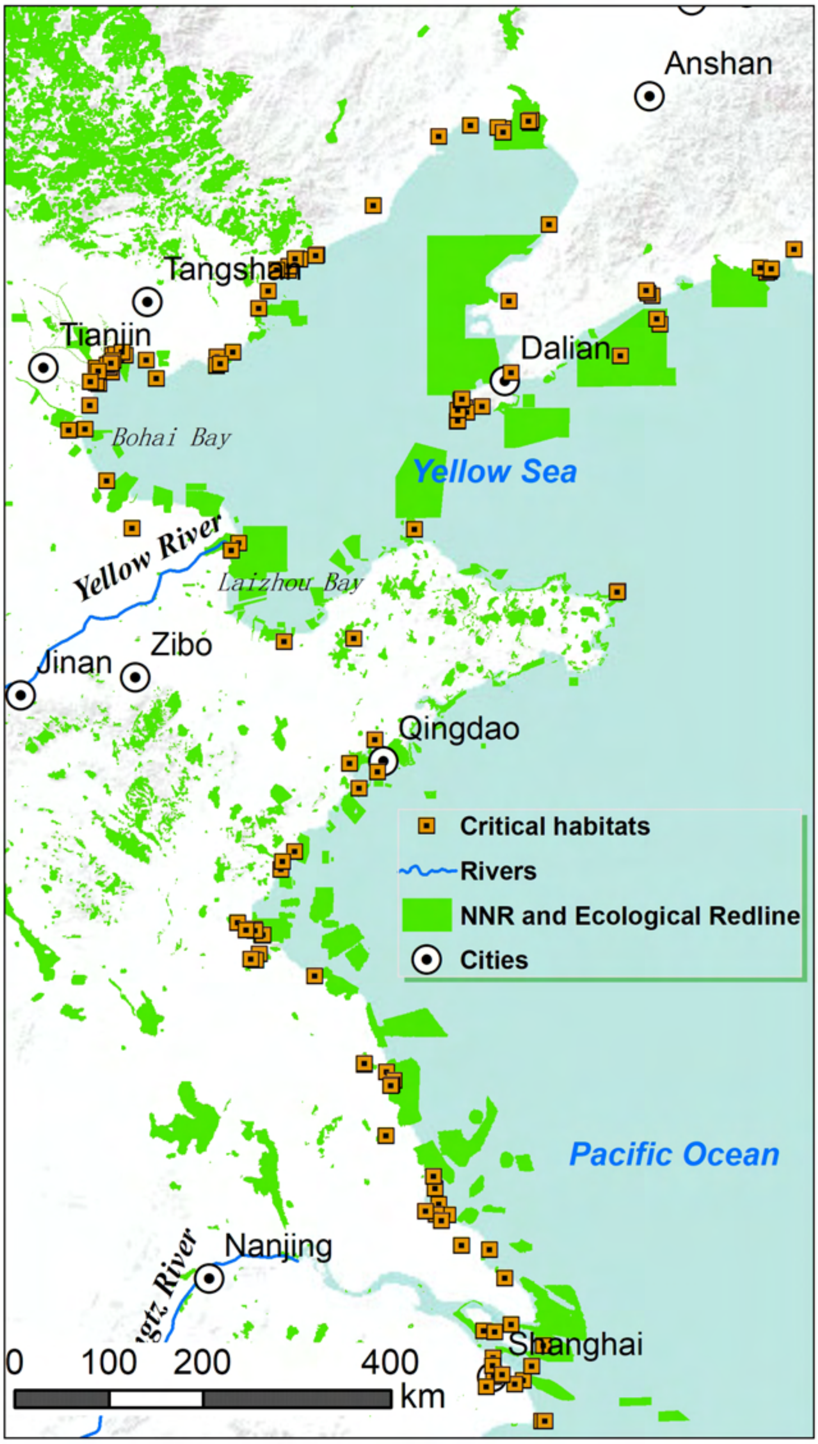
However, the acreage of mudflat matters in maintaining the total ecosystem productivity (Cui et al. 2016). Besides, the pollution, reclamation activity and alternation of hydrological connectivity are causes for composition of species (Bonilla et al. 2005, Cao et al. 2014), of which the change may lead to a low quality of habitats for species rely on the benthos for food, as the loss of some critical food source.

4 Conservation status and gaps

4.1 Conservation gaps on critical shorebird habitats

For a long period, natural reserves play important role in habitat conservation due to the stable financial investment and staff, and concrete legislation. Recently, ecological conservation redlines, which integrated other conservation spaces and the natural reserves, become the top conservation space in China. The central government ordered the provincial governments to plan the spatially specific redlines for ecological conservation before the end of 2018. The areas within redlines are strictly prohibited to development in any form. Most of the provincial administrations of China in the Yellow Sea region have announced the ecological conservation redlines as response to the order from central government as of August, 2018, except Liaoning (Figure 23), of which the Department of Ocean and Fisheries announced *the Ocean Ecological Conservation Redline for Yellow Sea* in December 2016 (Figure 23). The ecological conservation redlines covers National Natural Reserves and other conservation spaces. It enlarged the spatial coverage of habitat conservation (Figure 23). As illustrated by Figure 23, of the identified 137 critical bird habitats, 56 habitats on the coastal wetlands are covered by the national reserves and the ecological conservation redlines. However, 81 of the critical bird habitat sites are beyond ecological conservation redline and national natural reserves (Figure 23).

As to provincial level, the effectiveness of ecological redlines in covering critical bird habitat sites varies significantly. Jiangsu has the longest mush flat, 33 critical bird habitat sites were identified, and 22 were covered by protected areas including ecological redlines and national natural reserves (Table 3). At present,. Since the urbanized area occupies most coastal area of Shanghai and Tianjin, the percentage of critical bird habitats that covered by ecological redlines is very small. Of the 20 critical bird habitats identified in Tianjin, only 2 a located in areas of ecological redlines or national natural reserves. Shanghai has the similar situation, 3 were covered by protected areas. Liaoning has the largest number of critical bird habitats, however, of which 11 were covered by national natural reserves. To date, Liaoning hasn't accomplished the provincial level ecological redline planning, but for the Yellow Sea in the south of Liaodong peninsula (Figure 23).



Protected 56 Unprotected 81

Figure 23 Spatial intersection of critical bird habitats and conservation areas in the forms of ecological redlines and national natural reserves

Table 6 Statistics for critical bird habitats covered by announced redlines

Provinces	Protected	Unprotected	Number of Critical bird habitat sites
Liaoning	11	23	34
Hebei	8	12	20
Tianjin	2	18	20
Shandong	10	6	16
Jiangsu	22	11	33
Shanghai	3	14	17

Table 7 Summary of the status protection for the habitats of four shorebird categories

	Anatidae	Laridae	Waders	Stork and Crane
Protected	6	5	4	17
Unprotected	24	25	28	0

The protection rate of critical habitats for the four shorebird categories differs evidently. All of the 17 critical habitats for Stork and Crane are covered by the national natural reserves and ecological redlines. However, the protection rate of the critical habitats of Anatidae, Laridae, and Waders are rather low. This situation may be attributed to the large number of these species, widely distribution and low rank in ICUN red list. Of course, there are greater risks of their habitats to be occupied by reclamations. Anatidae, Laridae, and Waders depend on mud flats on ponds with shallow water due to the limitation of body size, peculiarly the length of foot. Their habitats mainly distribute in coast of Jiangsu, Yellow River delta, coast of Tianjin, southern coast of Hebei, Liaohe estuary and Yalujiang estuary, where the mud flat widely distributed. These areas also are very easy for reclamation and cultivation, and are productive. Therefore, conflicts between biodiversity conservation and economy development and residential livelihood are intense.

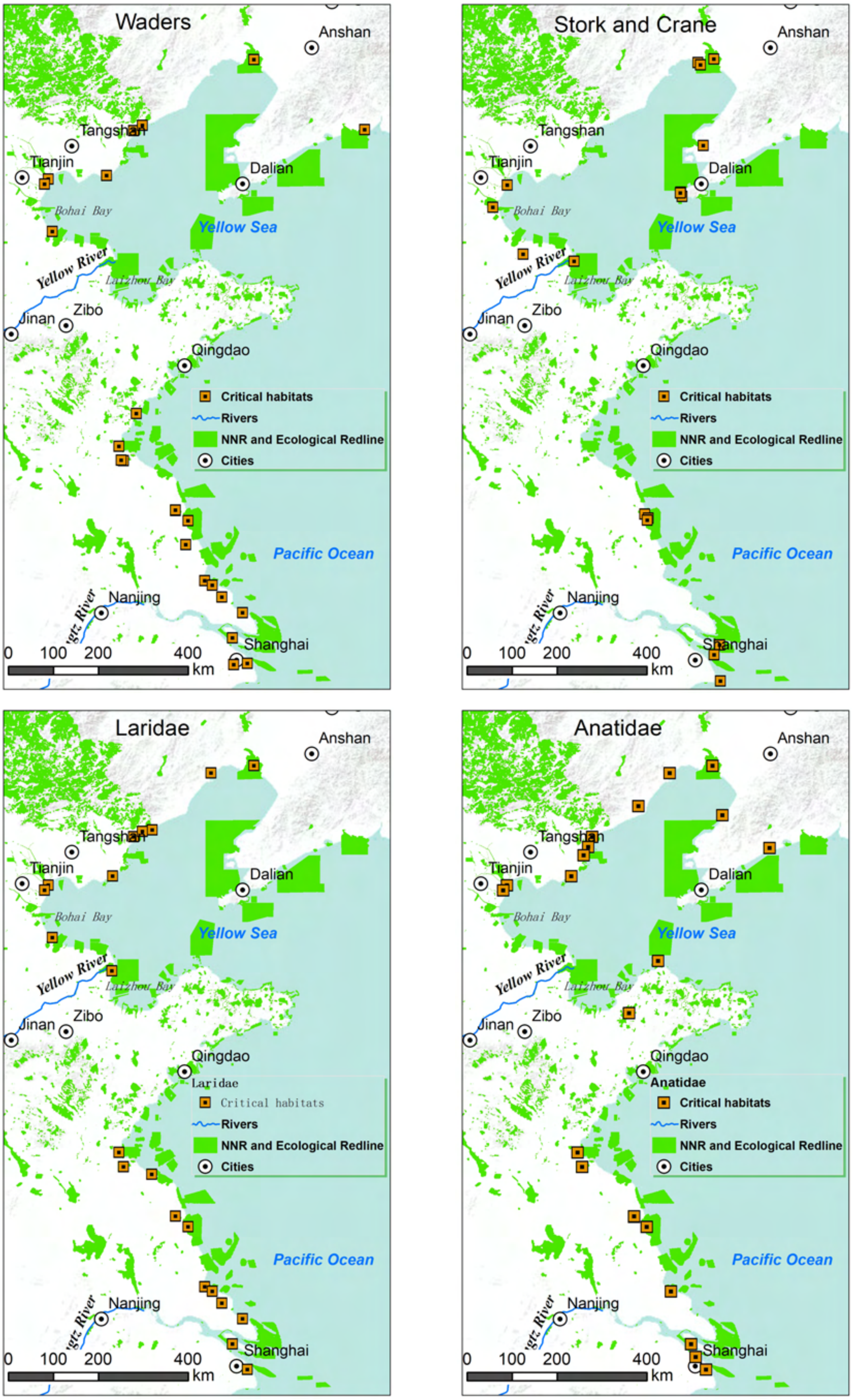


Figure 24 Spatial intersection between critical bird habitat of four shorebird categories and conservation areas in the forms of ecological redlines and national natural reserves

4.2 Conservation gaps on critical shellfish habitats

The critical habitats for shellfish, fish and shrimps in the Yellow Sea is of large area. Totally cover this area by protection in the form of concrete space is not feasible. Constraints provided by legislation on resource cultivation and partly covered by ecological redlines are the present protection mode. Therefore, if a critical habitat partly covered by announced ecological relines, we considered that it is under protection.

Figure 25 Spatial overly between protected areas, in the form of ecological redline and national natural reserves, and critical habitats for shellfish, fish and shrimp

Table 8 Status of habitat protection for shellfish in Yellow Sea, China

Sites	Protection status	Sites	Protection status
Liaodong Bay	Unprotected	Intertidal area of Changdao	Redline
Coast of Liaodong Peninsular	Ocean redline	Intertidal area of Yantai	Redline
Bohai bay	Redline	Intertidal area of Weihai	Redline
Intertidal area of Rushan	Redline	Intertidal area of Haiyang	Redline
Haizhou Bay (include Lianyungang)	Redline	Intertidal area of Qingdao	Redline
Intertidal area of Qinhuangdao	Unprotected	Intertidal area of Rizhao	Redline

Since the whole nation still on the way of urbanization, demands on coastal mud flat reclamation and resources exploration are still increase on a huge magnitude due to the regional economy growth and social development. As illustrated by Figure 26, the necessary protected areas for shore birds spatially overlay the planned reclamation on the mud flat in south Jiangsu coastal zone. To reconcile the conflicts is very difficult in the context of great demands on industrial booming to push economy growth, which is of great importance for resident livelihood. A resolution of compatible coastal land use is necessary.

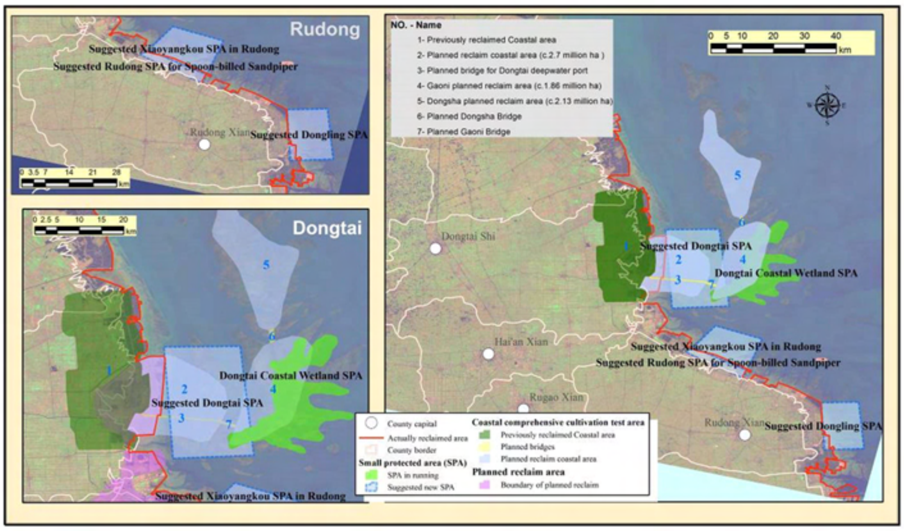


Figure 26 Spatial conflicts between habitats protection and reclamation actions

Gaps in shellfish habitat conservation

5 Proposals on management measures

Reclamation of the coastal marsh is an evitable need in many regions, such as the coastal areas of Jiangsu province. According to the *Outline of National Territory Planning of China (2016-2030),* GDP derived from ocean utilization is anticipated be up to 9.5% of the GDP of China in 2020, and this figure is anticipated to be 14% in 2030. In the achievement list of this planning, acreage of wetland is an anticipated indicator, not an obligatory indicator that has to be reached. The coastal zone is issued to more responsibility to engine the economy and accommodating more population. This implies an intensification of marine cultivation in various avenues such as reclamation, oil exploration, wind electricity production etc.

Table 9 Key achievement indicators given by the Outline of National Territory Planning of China (2016-2030)

Indicators	2015	2020	2030	Property
1. Arable land acreage (10^8 mu*)	18.65	18.65	18.25	Obligatory
2. Water consumption (10^8 m^3)	6180	6700	7000	Obligatory
3. Forest coverage (%)	21.66	＞23	＞24	anticipated
4. Steppe vegetation coverage (%)	54	56	60	anticipated
5. Wetland acreage (10^8 mu*)	8	8	8.3	anticipated
6. Land development intensity (%)	4.02	4.24	4.62	Obligatory
7. Urbanized area (10^4 km^2)	8.90	10.21	11.67	anticipated
8. Density of road and railway (km/km^2)	0.49	≥0.5	≥0.6	anticipated
9. Water quality achieved in seven key basins(%)	67.5	＞70	＞75	Obligatory
10. Water quality achieved in key lakes(%)	70.8	＞80	＞95	Obligatory
11. Increment of soil and water loss conservation area (10^4 km)	-	32	94	anticipated

* 1mu=0.0667 ha.

Undoubtedly, coastal wetlands will face an enhancing utilization to serve the economy development and livelihood of local communities. Beyond reducing the marsh flat reclamation, more wise strategies are necessary. According to the present status of coastal wetlands utilization and reclamation, some recommendations are given below.

5.1 Protect the opportunities for new habitat emerging

Protect the opportunities for emerging of new marshes is a choice to reconcile the conflicts between habitat conservation and marsh reclamation. Estuaries and coasts are conjunctions of four spheres (atmosphere, lithosphere, hydrosphere and biosphere) and important matter and energy convergence/divergence zones (Chen and Chen 2002). Sediment flow is of critical importance for maintenance of coastal marshes. Sustainable sediment flow form the terrestrial areas compensates sediment loss due to the erosion of ocean waves. However, in reclamation the channels or streams previously with sedimentological connectivity to the marshes are usually controlled by sluices (Figure 27 left). In some reclaimed coastal lines, the long continuous dikes are built (Figure 27 right), which totally cut off the sedimentological connectivity between marshes and their sediment sources in terrestrial ecosystems. These alternations on sediment flow inevitably deteriorate the situation of habitat loss.

Figure 27 Sediment flow cut off due to sluices construction (left and middle) and long continuous dikes (right) during reclamation

5.2 Keep the rolling relief

The natural marshes usually have a rolling relief (Figure 28). It provided diverse niches for diverse species and guarantees the safety of all species living on the marsh flat in the context of daily sea level rise and down. Therefore, the rolling relief is of critical importance for biodiversity conservation. However, due to the cut off of sediment flow from the terrestrial area by dikes and sluices, and the relief reshaping by dredging and filling engineering, the rolling relief disappeared near the seashores and replaced by relief with flat and cliffs (Figure 28). These changes in relief reduces the niche diversity and weakened the capacity of a marsh flat to accommodate more species. Therefore, maintain the sediment flow by change the long and continuous dikes into segments divided by sediment transport channels is a necessity. Reduce the impact of dredging and filling engineering on the rolling relief, or restore the rolling relief after the filling will benefit the limiting of negative impact to habitat quality.

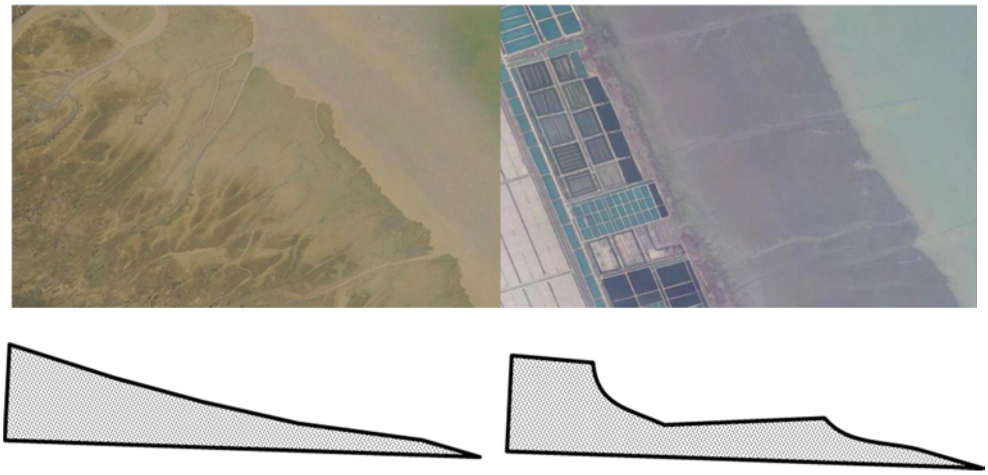


Figure 28 Difference in relief profile between natural marsh flat (left) and marsh flats beyond dikes (right)

5.3 Encourage synergy utilization of marsh and reclaimed coastal marsh

For some land uses on reclaimed coastal wetlands, utilization is compatible with biodiversity conservation, such as the salt pans and fish farming ponds. Carefully design the timing and develop compatible producing techniques and workflows usually are possible to biodiversity conservation.

5.4 Design habitat network for conservation as a resolution for fragmented landscape

Due to the reclamation and utilization of the coastal wetlands in the long history, it is impossible to sustain a habitat with a huge spatial dimension. The fragmentized habitats are common on the Yellow Sea wetlands. By design a habitat network to combine these habitats is a choice for ecological conservation. Corridors such as channels should be designed and ocean migration paths be identified to connect the habitat pieces to form a habitat network.

References

State Oceanic Administration, PRC., 2017. *The Measures for the Protection and Utilization of Coastlines.http://www.soa.gov.cn/zwgk/hygb/gjhyjgb/2017_2/201710/t20171026_58581.html, Accessed in 2018-06-12.*

State Oceanic Administration, PRC. (2018) Bulletin of China Marine Ecological Environment Status.http://www.soa.gov.cn/zwgk/hygb/zghyhjzlgb/201806/t20180606_61389.html (Accessed in 2018-09-11)

Xu Xinliang,Liu Jiyuan, Zhang Zengxiang, et al., 2015.Time Series of Land Ecosystem Classification Dataset of China in Five Yearly Steps (ChinaEco100) ,Global Change Research Data Publishing & Repository,DOI:10.3974/geodb.2015.01.01.V1.

Mundkur, T., Langendoen, T. and Watkins, D. (eds.), 2017. The Asian Waterbird Census 2008-2015: results of coordinated counts in Asia and Australasia. Wetlands International, Ede.

Chen Kelin, Bai Jiade, Jiang Ming, Chen Qi, Li Yanhui, Lv Yong, Doug Watkins, John Howes, Taej Mundkur, Yang Xiuzhi, Xie Jun, Zhang Xiaohong, 2016. Yellow Sea – Bohai region coordinated waterbird survey 2016. Summary report. Wetlands International - China, Beijing.

Bonilla, S., Conde, D., Aubriot, L. and Pérez, M.D.C. (2005) Influence of hydrology on phytoplankton species composition and life strategies in a subtropical coastal lagoon periodically connected with the Atlantic Ocean. Estuaries 28(6), 884-895.

Cao, H., Ge, Z., Zhu, Z. and Zhang, L. (2014) The expansion pattern of saltmarshed at Chongming Dongtan and its underlying mechanism. Acta Ecologica Sinica 34(14), 3944-3952.

Chen, J. and Chen, S. (2002) Estuarine and coastal challenges in China. Chinese Journal of Oceanology Limnology 20(2), 174-181.

Chen, K.L., Yang, X. and Lv, Y. (2015) Vital Stopover of Shorebirds Migration on the East Asian-Australasian Flyway:Wetlands of Yellow Sea and Bohai Sea. 13(1), 1-6.

Cui, B., He, Q., Gu, B., Bai, J. and Liu, X.J.W. (2016) China's Coastal Wetlands: Understanding Environmental Changes and Human Impacts for Management and Conservation. 36(1), 1-9.

Hua, N., Tan, K., Chen, Y. and Ma, Z. (2015) Key research issues concerning the conservation of migratory shorebirds in the Yellow Sea region.

Jin, X.S., Shan, X.J., Li, X.S., Wang, J., Yi, C. and Tao, Z.J.S.C.E.S. (2013) Long-term changes in the fishery ecosystem structure of Laizhou Bay, China. 56(3), 366-374.

Leng, Y., Liu, Y., Liu, S., Zhang, H., Zhang, A. and Liu, X. (2013) Community structure and diversity of macrobenthos in southern intertidal zone of Yellow River Delta, China. Chinese Journal of Ecology 32(11), 3054-3062.

Ma, Z., Melville, D., Liu, J., Chen, Y., Yang, H., Ren, W., Zhang, Z.-W., Piersma, T. and Li, B. (2014) Rethinking China's new great wall.

Meng, W., Qin, Y., Zheng, B. and Zhang, L. (2008) Heavy metal pollution in Tianjin Bohai Bay, China. Journal of Environmental Sciences 20(7), 814-819.

Murray, N.J., Clemens, R.S., Phinn, S.R., Possingham, H.P. and Fuller, R.A.J.B.o.t.E.S.o.A. (2015) Threats to the Yellow Sea's Tidal Wetlands. 96(2), 346-348.

Que, P., Chang, Y., Eberhart-Phillips, L., Liu, Y., Székely, T. and Zhang, Z. (2015) Low nest survival of a breeding shorebird in Bohai Bay, China. Journal of Ornithology 156(1), 297-307.

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.C., Straw, P., Woehler, E.J. and Fuller, R.A. (2017) Rapid population decline in migratory shorebirds relying on Yellow Sea tidal mudflats as stopover sites. Nature Communications 8, 14895.

Szabo, J.K., Choi, C.-Y., Clemens, R.S. and Hansen, B. (2016) Conservation without borders—solutions to declines of migratory shorebirds in the East Asian—Australasian Flyway. Emu - Austral Ornithology 116(2), 215-221.

Wang, W., Liu, H., Li, Y. and Su, J. (2014) Development and management of land reclamation in China. Ocean Coastal Management 102, 415-425.

Yang, H.Y., Chen, B., Ma, Z.J., Hua, N., van Gils, J.A., Zhang, Z.W. and Piersma, T.J.J.o.E.B. (2013) Economic design in a long-distance migrating molluscivore: how fast-fuelling red knots in Bohai Bay, China, get away with small gizzards. 216(19), 3627-3636.

Yong, D.L., Jain, A., Liu, Y., Iqbal, M., Choi, C.Y., Crockford, N.J., Millington, S. and Provencher, J.J.C.B. (2017) Challenges and opportunities for transboundary conservation of migratory birds in the East Asian-Australasian flyway. 32(3), 740-743.

Zhang, H., Tang, X., Guo, Z., Liu, P., Shi, J., Yu, W., Fen, C. and Yuan, J. (2014) Temporal and spatial distribution of benthic macrofauna in intertidal mudflat of central and southern Jiangsu coast. 36(3), 208-215.

Appendix

Appendix 1 Bird species covered by the records used in this report

NO.	Common Name	Scientific name	NO.	Common Name	Scientific name
1	Aleutian Tern	*Sterna aleutica*	**136**	Little Grebe	*Tachybaptus ruficollis*
2	Ancient Murrelet	*Synthliboramphus antiquus*	**137**	Little Gull	*Larus minutus*
3	Asian Dowitcher	*Limnodromus semipalmatus*	**138**	Little Ringed Plover	*Charadrius dubius*
4	Asian Openbill	*Anastomus oscitans*	**139**	Little Stint	*Calidris minuta*
5	Baer's Pochard	*Aythya baeri*	**140**	Little Tern	*Sterna albifrons*
6	Baikal Teal	*Anas formosa*	**141**	Long-billed Dowitcher	*Limnodromus scolopaceus*
8	Baillon's Crake	*Porzana pusilla*	**142**	Long-billed Murrelet	*Brachyramphus perdix*
9	Band-bellied Crake	*Porzana paykullii*	**143**	Long-billed Plover	*Charadrius placidus*
10	Bar-headed Goose	*Anser indicus*	**144**	Long-tailed Duck	*Clangula hyemalis*
11	Bar-tailed Godwit	*Limosa lapponica*	**145**	Long-tailed Jaeger	*Stercorarius longicaudus*
12	Bean goose	*Anser fabalis*	**146**	Long-toed Stint	*Calidris subminuta*
13	Black Bittern	*Dupetor flavicollis*	**147**	Macqueen's Bustard	*Chlamydotis macqueenii*
14	Black Kite	*Milvus migrans*	**148**	Malayan Night Heron	*Gorsachius melanolophus*
15	Black Stork	*Ciconia nigra*	**149**	Mallard	*Anas platyrhynchos*
16	Black Tern	*Chlidonias niger*	**150**	Mandarin Duck	*Aix galericulata*
17	Black-capped Kingfisher	*Halcyon pileata*	**151**	Marbled Murrelet	*Marmaronetta angustirostris*
18	Black-crowned Night Heron	*Nycticorax nycticorax*	**152**	Marsh Sandpiper	*Tringa stagnatilis*
19	Black-faced Spoonbill	*Platalea minor*	**153**	Masked Booby	*Sula dactylatra*
20	Black-headed Ibis	*Threskiornis melanocephalus*	**154**	Mew Gull	*Larus canus*
21	Black-legged Kittiwake	*Rissa tridactyla*	**155**	Mongolian Gull	*Larus mongolicus*
22	Black-naped Tern	*Sterna sumatrana*	**156**	Mute swan	*Cygnus olor*
23	Black-necked Crane	*Grus nigricollis*	**157**	Nordmann's Greenshank	*Tringa guttifer*
24	Black-necked Grebe	*Podiceps nigricollis*	**158**	Northern Harrier	*Circus cyaneus*
25	Black-tailed Crake	*Porzana bicolor*	**159**	Northern Lapwing	*Vanellus vanellus*
26	Black-tailed Godwit	*Limosa limosa*	**160**	Northern Pintail	*Anas acuta*

NO.	Common Name	Scientific name	NO.	Common Name	Scientific name
27	Black-tailed Gull	*Larus crassirostris*	**161**	Northern Shoveler	*Anas clypeata*
28	Black-throated loon	*Gavia arctica*	**162**	Oriental (White) Stork	*Ciconia boyciana*
29	Black-winged Kite	*Elanus caeruleus*	**163**	Oriental Plover	*Charadrius veredus*
30	Black-winged Stilt	*Himantopus himantopus*	**164**	Oriental Pratincole	*Glareola maldivarum*
31	Bonin Petrel	*Pterodroma hypoleuca*	**165**	Oriental Stork	*Ciconia boyciana*
32	Brent Goose	*Branta bernicla*	**166**	Osprey	*Pandion haliaetus*
33	Bridled Tern	*Sterna anaethetus*	**167**	Pacific Golden Plover	*Pluvialis fulva*
34	Broad-billed Sandpiper	*Limicola falcinellus*	**168**	Pacific loon	*Gavia pacifica*
35	Brown Booby	*Sula leucogaster*	**169**	Pacific Reef Heron	*Egretta sacra*
36	Brown Crake	*Amaurornis akool*	**170**	Pallas's Fish Eagle	*Haliaeetus leucoryphus*
37	Brown Noddy	*Anous stolidus*	**171**	Pallas's Gull	*Larus ichthyaetus*
38	Brown-headed Gull	*Larus brunnicephalus*	**172**	Parasitic Jaeger	*Stercorarius parasiticus*
39	Buff-breasted Sandpiper	*Tryngites subruficollis*	**173**	Pectoral Sandpiper	*Calidris melanotos*
40	Caspian Tern	*Hydroprogne caspia*	**174**	Peregrine Falcon	*Falco peregrinus*
41	Cattle Egret	*Bubulcus ibis*	**175**	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
42	Chinese Egret	*Egretta eulophotes*	**176**	Pied Avocet	*Recurvirostra avosetta*
43	Chinese Little Bittern	*Ixobrychus sinensis*	**177**	Pied Heron	*Egretta picata*
44	Chinese Pond Heron	*Ardeola bacchus*	**178**	Pied Kingfisher	*Ceryle rudis*
45	Christmas Island Frigatebird	*Fregata andrewsi*	**179**	Pintail Snipe	*Gallinago stenura*
46	Cinnamon Bittern	*Ixobrychus cinnamomeus*	**180**	Pomarine Jaeger	*Stercorarius pomarinus*
47	Collared Crow	*Corvus pectoralis*	**181**	Purple Heron	*Ardea purpurea*
48	Collared Pratincole	*Glareola pratincola*	**182**	Purple Swamphen	*Porphyrio porphyrio*
49	Common Black-headed Gull	*Larus ridibundus*	**183**	Red Knot	*Calidris canutus*
50	Common Buzzard	*Buteo buteo*	**184**	Red Phalarope	*Phalaropus fulicarius*
51	Common Crane	*Grus grus*	**185**	Red-billed Starling	*Sturnus sericeus*
52	Common Goldeneye	*Bucephala clangula*	**186**	Red-breasted Goose	*Branta ruficollis*
53	Common Greenshank	*Tringa nebularia*	**187**	Red-breasted Merganser	*Mergus serrator*
54	Common Kingfisher	*Alcedo atthis*	**188**	Red-crested	*Netta rufina*

NO.	Common Name	Scientific name	NO.	Common Name	Scientific name
				Pochard	
55	Common merganser	*Mergus merganser*	**189**	Red-crowned Crane	*Grus japonensis*
56	Common Moorhen	*Gallinula chloropus*	**190**	Red-footed Booby	*Sula sula*
57	Common Pochard	*Aythya ferina*	**191**	Red-necked Grebe	*Podiceps grisegena*
58	Common Redshank	*Tringa totanus*	**192**	Red-necked Phalarope	*Phalaropus lobatus*
59	Common Ringed Plover	*Charadrius hiaticula*	**193**	Red-necked Stint	*Calidris ruficollis*
60	Common Sandpiper	*Actitis hypoleucos*	**194**	Red-throated loon	*Gavia stellata*
61	Common Shelduck	*Tadorna tadorna*	**195**	Red-wattled Lapwing	*Vanellus indicus*
62	Common Snipe	*Gallinago gallinago*	**196**	Relict Gull	*Larus relictus*
63	Common Tern	*Sterna hirundo*	**197**	Ringed Plover	*Charadrius hiaticula*
64	Coot	*Fulica atra*	**198**	River Lapwing	*Vanellus duvaucelii*
65	Corn Crake	*Crex crex*	**199**	River Tern	*Sterna aurantia*
66	Cotton Pygmy Goose	*Nettapus coromandelianus*	**200**	Roseate Tern	*Sterna dougallii*
67	Crested Ibis	*Nipponia nippon*	**201**	Ruddy Shelduck	*Tadorna ferruginea*
68	Curlew Sandpiper	*Calidris ferruginea*	**202**	Ruddy Turnstone	*Arenaria interpres*
69	Dalmatian Pelican	*Pelecanus crispus*	**203**	Ruddy-breasted Crake	*Porzana fusca*
70	Demoiselle Crane	*Grus virgo*	**204**	Ruff	*Philomachus pugnax*
71	Dunlin	*Calidris alpina*	**205**	Sanderling	*Calidris alba*
72	Eastern Curlew	*Numenius madagascariensis*	**206**	Sandhill Crane	*Grus canadensis*
73	Eastern Imperial Eagle	*Aquila heliaca*	**207**	Saunders's Gull	*Larus saundersi*
74	Eastern Marsh Harrier	*Circus spilonotus*	**208**	Scaly-sided Merganser	*Mergus squamatus*
75	Eurasian Bittern	*Botaurus stellaris*	**209**	Schrenck's Little Bittern	*Ixobrychus eurhythmus*
76	Eurasian Curlew	*Numenius arquata*	**210**	Sharp-tailed Sandpiper	*Calidris acuminata*
77	Eurasian Dotterel	*Charadrius morinellus*	**211**	Short-tailed Albatross	*Phoebastria albatrus*
78	Eurasian Oystercatcher	*Haematopus ostralegus*	**212**	Short-tailed Shearwater	*Puffinus tenuirostris*
79	Eurasian Spoonbill	*Platalea leucorodia*	**213**	Siberian crane	*Leucogeranus leucogeranus*
80	Eurasian Teal	*Anas crecca*	**214**	Siberian White Crane	*Grus leucogeranus*
81	Eurasian Thick-knee	*Burhinus oedicnemus*	**215**	Slaty-backed Gull	*Larus schistisagus*

NO.	Common Name	Scientific name	NO.	Common Name	Scientific name
82	Eurasian wigeon	*Anas penelope*	**216**	Slaty-breasted Banded Rail	*Gallirallus striatus*
84	Eurasian Woodcock	*Scolopax rusticola*	**217**	Slaty-breasted Rail	*Gallirallus striatus*
85	Falcated Duck	*Anas falcata*	**218**	Slaty-legged Crake	*Rallina eurizonoides*
86	Far Eastern Curlew	*Numenius madagascariensis*	**219**	Slender-billed Gull	*Larus genei*
87	Ferruginous Duck	*Aythya nyroca*	**220**	Small Pratincole	*Glareola lactea*
88	Ferruginous Pochard	*Aythya nyroca*	**221**	Smew	*Mergellus albellus*
89	Gadwall	*Anas strepera*	**222**	Snow Goose	*Chen caerulescens*
90	Garganey	*Anas querquedula*	**223**	Solitary Snipe	*Gallinago solitaria*
91	Glaucous Gull	*Larus hyperboreus*	**224**	Sooty Tern	*Sterna fuscata*
92	Glaucous-winged Gull	*Larus glaucescens*	**225**	South polar Skua	*Stercorarius maccormicki*
93	Glossy Ibis	*Plegadis falcinellus*	**226**	Spoon-billed Sandpiper	*Eurynorhynchus pygmeus*
94	Great Bittern	*Botaurus stellaris*	**227**	Spot-billed Duck	*Anas poecilorhyncha*
95	Great Black-headed (Pallas's) Gull	*Larus ichthyaetus*	**228**	Spotted Crake	*Porzana porzana*
96	Great Bustard	*Otis tarda*	**229**	Spotted Redshank	*Tringa erythropus*
97	Great Cormorant	*Phalacrocorax carbo*	**230**	Steller's Sea Eagle	*Haliaeetus pelagicus*
98	Great Crested Grebe	*Podiceps cristatus*	**231**	Streaked Shearwater	*Calonectris leucomelas*
99	Great Crested Tern	*Sterna bergii*	**232**	Striated Heron	*Butorides striata*
100	Great Egret	*Casmerodius albus*	**233**	Swan goose	*Anser cygnoides*
101	Great Knot	*Calidris tenuirostris*	**234**	Swinhoe’s Rail	*Coturnicops exquisitus*
102	Great White Pelican	*Pelecanus onocrotalus*	**235**	Swinhoe's Snipe	*Gallinago megala*
103	Greater Painted-snipe	*Rostratula benghalensis*	**236**	Swinhoe's Storm-petrel	*Oceanodroma monorhis*
104	Greater Sand plover	*Charadrius leschenaultii*	**237**	Tahiti Petrel	*Pseudobulweria rostrata*
105	Greater Scaup	*Aythya marila*	**238**	Temminck's Stint	*Calidris temminckii*
106	Greater Spotted Eagle	*Aquila clanga*	**239**	Terek Sandpiper	*Xenus cinereus*
107	Greater white-fronted goose	*Anser albifrons*	**240**	Tufted duck	*Aythya fuligula*
108	Green Sandpiper	*Tringa ochropus*	**241**	Tundra swan	*Cygnus columbianus*
109	Green-backed Heron	*Butorides striata*	**242**	Vega Gull	*Larus vegae*
110	Grey Heron	*Ardea cinerea*	**243**	Von Schrenck's Bittern	*Ixobrychus eurhythmus*
111	Grey leg goose	*Anser anser*	**244**	Wandering Tattler	*Heteroscelus incanus*
112	Grey Plover	*Pluvialis squatarola*	**245**	Water Rail	*Rallus aquaticus*

NO.	Common Name	Scientific name	NO.	Common Name	Scientific name
113	Grey-headed Lapwing	*Vanellus cinereus*	**246**	Watercock	*Gallicrex cinerea*
114	Greylag Goose	*Anser anser*	**247**	Western Marsh Harrier	*Circus aeruginosus*
115	Grey-tailed Tattler	*Heteroscelus brevipes*	**248**	Whimbrel	*Numenius phaeopus*
116	Gull-billed Tern	*Gelochelidon nilotica*	**249**	Whiskered Tern	*Chlidonias hybrida*
117	Herring Gull	*Larus argentatus*	**250**	white spoonbil	*Platalea leucorodia*
118	Heuglin's Gull	*Larus heuglini*	**251**	White-bellied Eagle	*Haliaeetus leucogaster*
119	Hooded Crane	*Grus monacha*	**252**	White-breasted Waterhen	*Amaurornis phoenicurus*
120	Horned Grebe	*Podiceps auritus*	**253**	White-eared Night Heron	*Gorsachius magnificus*
121	Ibisbill	*Ibidorhyncha struthersii*	**254**	White-headed Duck	*Oxyura leucocephala*
122	Intermediate Egret	*Mesophoyx intermedia*	**255**	White-naped Crane	*Grus vipio*
123	Jack Snipe	*Lymnocryptes minimus*	**256**	White-rumped Sandpiper	*Calidris fuscicollis*
124	Japanese Cormorant	*Phalacrocorax capillatus*	**257**	White-tailed Sea Eagle	*Haliaeetus albicilla*
125	Kentish Plover	*Charadrius alexandrinus*	**258**	White-tailed Tropicbird	*Phaethon lepturus*
126	Lesser Crested Tern	*Sterna bengalensis*	**259**	White-throated Kingfisher	*Halcyon smyrnensis*
127	Lesser Frigatebird	*Fregata ariel*	**260**	White-winged Black Tern	*Chlidonias leucopterus*
128	Lesser Sand Plover	*Charadrius mongolus*	**262**	White-winged Scoter	*Melanitta fusca*
129	Lesser Whistling Duck	*Dendrocygna javanica*	**263**	White-winged Tern	*Chlidonias leucoptera*
130	Lesser white-fronted goose	*Anser erythropus*	**264**	Whooper swan	*Cygnus cygnus*
131	Little Bittern	*Ixobrychus minutus*	**265**	Wood Sandpiper	*Tringa glareola*
132	Little Bustard	*Tetrax tetrax*	**266**	Wood Snipe	*Gallinago nemoricola*
133	Little Cormorant	*Phalacrocorax niger*	**267**	Yellow Bittern	*Ixobrychus sinensis*
134	Little Curlew	*Numenius minutus*	**268**	Yellow-legged Gull	*Larus cachinnans*
135	Little Egret	*Egretta garzetta*			

Appendix 2 List of the critical habitats for shorebirds

NO.	Province	County	Longitude	Latitude
1	Liaoning	Lüshunkou	121.65584	39.09135
2	Liaoning	Lüshunkou	121.21065	38.83486
3	Liaoning	Lüshunkou	121.23346	38.79885
4	Liaoning	Lüshunkou	121.14303	38.73247
5	Liaoning	Lüshunkou	121.14884	38.73676
6	Liaoning	Lüshunkou	121.37666	38.84278
7	Liaoning	Lüshunkou	121.18671	38.89930
8	Liaoning	Lüshunkou	121.14624	38.81249
9	Liaoning	Lüshunkou	121.17495	38.88726
10	Liaoning	Wafangdian	121.63777	39.62169
11	Liaoning	Zhuanghe	123.07739	39.45235
12	Liaoning	Zhuanghe	123.05084	39.49039
13	Liaoning	Zhuanghe	123.00612	39.66074
14	Liaoning	Donggang	124.12483	39.84069
15	Liaoning	Donggang	124.10086	39.83452
16	Liaoning	Zhenxing	124.13082	39.84926
17	Liaoning	Linghai	124.36339	40.00451
18	Liaoning	Linghai	121.58318	40.88441
19	Liaoning	Linghai	121.26927	40.90447
20	Liaoning	Linghai	121.52926	40.89220
21	Liaoning	Dawa	121.83911	40.92369
22	Liaoning	Dawa	121.84894	40.94336
23	Liaoning	Panshan	121.58153	40.85648
24	Liaoning	Gaizhou	122.01810	40.18450
25	Liaoning	Zhuanghe	122.96190	39.68000
26	Liaoning	Jinzhou	120.96730	40.82680
27	Liaoning	Donggang	124.03690	39.86860
28	Liaoning	Suizhong	120.33870	40.32420
29	Liaoning	Lüshunkou	121.18580	38.89640
30	Liaoning	Zhuanghe	122.96190	39.68000
31	Liaoning	Donggang	124.14690	39.86150
32	Liaoning	Yingkou	121.82410	40.93670
33	Liaoning	Rugao	120.25330	33.77620
34	Liaoning	Zhuanghe	122.94790	39.70090
35	Hebei	Beidaihe	119.49887	39.85474
36	Hebei	Beidaihe	119.52620	39.84921
37	Hebei	Beidaihe	119.52978	39.88106
38	Hebei	Haigai	119.61357	39.93617
39	Hebei	Haigai	119.63988	39.92937
40	Hebei	Shanhaiguan	119.79783	39.96560

41	Hebei	Leting	118.84343	39.20971
42	Hebei	Leting	118.83976	39.14182
43	Hebei	Leting	118.84306	39.14778
44	Hebei	Luannan	118.26453	39.05065
45	Hebei	Tanghai	118.17038	39.18616
46	Hebei	Beidaihe	119.41470	39.85100
47	Hebei	Beidaihe	119.59470	39.93430
48	Hebei	Huanghua	117.79110	38.28380
49	Hebei	Changli	119.33410	39.69670
50	Hebei	Leting	118.99570	39.24400
51	Hebei	Leting	118.87590	39.16020
52	Hebei	Shanhaiguan	119.78750	39.95520
53	Hebei	Lüshunkou	122.70130	39.21710
54	Hebei	Beidaihe	119.59470	39.93430
55	Tianjin	Binhaixinqu	117.71711	39.00951
56	Tianjin	Binhaixinqu	117.69029	39.12692
57	Tianjin	Binhaixinqu	117.96892	39.22237
58	Tianjin	Binhaixinqu	117.63014	38.84818
59	Tianjin	Binhaixinqu	117.84811	39.22257
60	Tianjin	Binhaixinqu	117.82339	39.15882
61	Tianjin	Binhaixinqu	117.83618	39.09646
62	Tianjin	Binhaixinqu	117.42913	38.66588
63	Tianjin	Binhaixinqu	117.81597	39.13350
64	Tianjin	Binhaixinqu	117.87659	39.22894
65	Tianjin	Binhaixinqu	117.93514	39.24664
66	Tianjin	Binhaixinqu	117.85133	39.18412
67	Tianjin	Binhaixinqu	117.79727	39.15088
68	Tianjin	Binhaixinqu	117.83279	39.16186
69	Tianjin	Binhaixinqu	117.68968	39.01847
70	Tianjin	Binhaixinqu	117.58594	38.67226
71	Tianjin	Binhaixinqu	117.71190	39.10560
72	Tianjin	Ninghe	119.24240	39.56790
73	Tianjin	Binhaixinqu	117.63490	39.02690
74	Shandong	Wudi	118.03207	37.92738
75	Shandong	Kenli	119.05387	37.81526
76	Shandong	Chengyang	120.35556	36.31328
77	Shandong	Huangdao	120.20563	35.94093
78	Shandong	Huangdao	120.11377	36.12977
79	Shandong	Donggang	119.45544	35.30649
80	Shandong	Donggang	119.58693	35.44570
81	Shandong	Rongcheng	122.67844	37.45427
82	Shandong	Changyi	119.48609	37.06635
83	Shandong	Shibei	120.37750	36.06680

84	Shandong	Penglai	120.73160	37.92060
85	Shandong	Dongying	118.98360	37.75980
86	Shandong	Rongcheng	122.67030	37.44430
87	Shandong	Donggang	119.47250	35.36970
88	Shandong	Donggang	119.21570	34.59760
89	Shandong	Laizhou	120.15320	37.09170
90	Jiangsu	Ganyu	119.20479	34.84053
91	Jiangsu	Ganyu	119.04140	34.88953
92	Jiangsu	Lianyun	119.27453	34.79211
93	Jiangsu	Lianyun	119.28638	34.79436
94	Jiangsu	Lianyun	119.20737	34.83013
95	Jiangsu	Hai’an	120.96678	32.65217
96	Jiangsu	Rudong	121.44823	32.28379
97	Jiangsu	Rudong	121.05244	32.56470
98	Jiangsu	Rudong	121.05239	32.56388
99	Jiangsu	Rudong	120.94186	32.56974
100	Jiangsu	Dongtai	120.93226	32.77894
101	Jiangsu	Dongtai	120.91695	32.87365
102	Jiangsu	Sheyang	120.46578	33.71280
103	Jiangsu	Sheyang	120.53859	33.64378
104	Jiangsu	Tinghu	120.51558	33.60852
105	Jiangsu	Lianyun	119.21570	34.59760
106	Jiangsu	Lianyun	119.21570	34.59760
107	Jiangsu	Tongzhou	121.18280	32.31780
108	Jiangsu	Ganyu	119.12210	34.83470
109	Jiangsu	Haizhou	119.25080	34.64560
110	Jiangsu	Hai’an	120.83910	32.59590
111	Jiangsu	Lianyun	119.21570	34.59760
112	Jiangsu	Lianyun	119.21570	34.59760
113	Jiangsu	Rudong	120.25380	33.76960
114	Jiangsu	Qidong	121.59860	32.05520
115	Jiangsu	Dafeng	120.46120	33.20070
116	Jiangsu	Rudong	121.18280	32.31780
117	Jiangsu	Lianyun	119.17070	34.60630
118	Jiangsu	Rudong	120.99200	32.51840
119	Jiangsu	Guanyun	120.50400	33.60200
120	Jiangsu	Jinzhou	119.77690	34.47300
121	Shanghai	Pudong	121.94869	30.88644
122	Shanghai	Pudong	121.98047	30.88803
123	Shanghai	Pudong	121.77034	31.22103
124	Shanghai	Zhabei	121.48790	31.24916
125	Shanghai	Chongming	121.65437	31.67486
126	Shanghai	Chongming	121.96552	31.50342

127	Shanghai	Chongming	121.85482	31.33816
128	Shanghai	Baoshan	121.48510	31.40740
129	Shanghai	Chongming	121.39270	31.62530
130	Shanghai	Chongming	121.39270	31.62530
131	Shanghai	Chongming	121.39270	31.62530
132	Shanghai	Zhabei	121.41750	31.16650
133	Shanghai	Chongming	121.69370	31.18880
134	Shanghai	Pudong	121.69370	31.18880
135	Shanghai	Pudong	121.48220	31.34280
136	Shanghai	Baoshan	121.57080	31.26880
137	Shanghai	Changxing	121.50000	31.61540

Appendix 3 List of the critical habitats for Anatidae

NO.	Province	County	Longitude	Latitude
1	Liaoning	Gaizhou	122.01810	40.18450
2	Shandong	Penglai	120.73160	37.92060
3	Shanghai	Baoshan	121.48510	31.40740
4	Shanghai	Chongming	121.39270	31.62530
5	Hebei	Beidaihe	119.49887	39.85474
6	Tianjin	Binhaixinqu	117.71190	39.10560
7	Jiangsu	Lianyun	119.21570	34.59760
8	Liaoning	Zhuanghe	122.96190	39.68000
9	Liaoning	Jinzhou	120.96730	40.82680
10	Jiangsu	Lianyun	119.21570	34.59760
11	Jiangsu	Ganyu	119.12210	34.83470
12	Shanghai	Chongming	121.39270	31.62530
13	Shanghai	Chongming	121.85482	31.33816
14	Hebei	Changli	119.33410	39.69670
15	Hebei	Leting	118.99570	39.24400
16	Shanghai	Chongming	121.69370	31.18880
17	Jiangsu	Lianyun	119.21570	34.59760
18	Jiangsu	Lianyun	119.21570	34.59760
19	Liaoning	Suizhong	120.33870	40.32420
20	Jiangsu	Rudong	120.25380	33.76960
21	Tianjin	Ninghe	119.24240	39.56790
22	Shandong	Donggang	119.21570	34.59760
23	Shanghai	Pudong	121.77034	31.22103
24	Liaoning	Zhuanghe	122.96190	39.68000
25	Liaoning	Yingkou	121.82410	40.93670
26	Liaoning	Rugao	120.25330	33.77620
27	Tianjin	Binhaixinqu	117.63490	39.02690
28	Shandong	Laizhou	120.15320	37.09170
29	Jiangsu	Rudong	121.05239	32.56388
30	Jiangsu	Guanyun	120.50400	33.60200

Appendix 4 List of the critical habitats for Waders

NO.	Province	County	Longitude	Latitude
1	Shanghai	Chongming	121.39270	31.62530
2	Hebei	Beidaihe	119.49887	39.85474
3	Tianjin	Binhaixinqu	117.71190	39.10560
4	Jiangsu	Lianyun	119.21570	34.59760
5	Jiangsu	Lianyun	119.21570	34.59760
6	Jiangsu	Tongzhou	121.18280	32.31780
7	Liaoning	Donggang	124.03690	39.86860
8	Shandong	Donggang	119.45544	35.30649
9	Jiangsu	Ganyu	119.12210	34.83470
10	Shanghai	Chongming	121.39270	31.62530
11	Hebei	Beidaihe	119.59470	39.93430
12	Shanghai	Chongming	121.85482	31.33816
13	Hebei	Huanghua	117.79110	38.28380
14	Shanghai	Zhabei	121.48790	31.24916
15	Shanghai	Chongming	121.69370	31.18880
16	Hebei	Leting	118.87590	39.16020
17	Jiangsu	Hai’an	120.83910	32.59590
18	Jiangsu	Lianyun	119.21570	34.59760
19	Jiangsu	Lianyun	119.21570	34.59760
20	Jiangsu	Rudong	120.25380	33.76960
21	Jiangsu	Qidong	121.59860	32.05520
22	Jiangsu	Dafeng	120.46120	33.20070
23	Shandong	Donggang	119.21570	34.59760
24	Jiangsu	Rudong	121.18280	32.31780
25	Shanghai	Pudong	121.77034	31.22103
26	Liaoning	Yingkou	121.82410	40.93670
27	Liaoning	Rugao	120.25330	33.77620
28	Tianjin	Binhaixinqu	117.63490	39.02690
29	Jiangsu	Lianyun	119.17070	34.60630
30	Jiangsu	Rudong	121.05239	32.56388
31	Hebei	Haigai	119.63988	39.92937
32	Jiangsu	Guanyun	120.50400	33.60200

Appendix 5 List of the critical habitats for Laridae

NO.	Province	County	Longitude	Latitude
1	Shanghai	Chongming	121.39270	31.62530
2	Hebei	Beidaihe	119.49887	39.85474
3	Shandong	Dongying	118.98360	37.75980
4	Tianjin	Binhaixinqu	117.71190	39.10560
5	Jiangsu	Lianyun	119.21570	34.59760
6	Liaoning	Jinzhou	120.96730	40.82680
7	Jiangsu	Lianyun	119.21570	34.59760
8	Jiangsu	Tongzhou	121.18280	32.31780
9	Jiangsu	Ganyu	119.12210	34.83470
10	Shanghai	Chongming	121.39270	31.62530
11	Hebei	Beidaihe	119.59470	39.93430
12	Shanghai	Chongming	121.85482	31.33816
13	Hebei	Huanghua	117.79110	38.28380
14	Hebei	Leting	118.99570	39.24400
15	Shanghai	Chongming	121.69370	31.18880
16	Jiangsu	Hai'an	120.83910	32.59590
17	Jiangsu	Lianyun	119.21570	34.59760
18	Jiangsu	Lianyun	119.21570	34.59760
19	Jiangsu	Qidong	121.59860	32.05520
20	Shandong	Donggang	119.21570	34.59760
21	Jiangsu	Rudong	121.18280	32.31780
22	Shanghai	Pudong	121.77034	31.22103
23	Hebei	Shanhaiguan	119.79783	39.96560
24	Liaoning	Yingkou	121.82410	40.93670
25	Liaoning	Rugao	120.25330	33.77620
26	Tianjin	Binhaixinqu	117.63490	39.02690
27	Jiangsu	Rudong	121.05239	32.56388
28	Hebei	Haigai	119.63988	39.92937
29	Jiangsu	Guanyun	120.50400	33.60200
30	Jiangsu	Jinzhou	119.77690	34.47300

Appendix 6 List of the critical habitats for Stork and Crane

NO.	Province	County	Longitude	Latitude
1	Jiangsu	Sheyang	120.46578	33.71280
2	Jiangsu	Sheyang	120.53859	33.64378
3	Jiangsu	Tinghu	120.51558	33.60852
4	Liaoning	Lüshunkou	121.21065	38.83486
5	Liaoning	Lüshunkou	121.18671	38.89930
6	Liaoning	Lüshunkou	121.17495	38.88726
7	Liaoning	Wafangdian	121.63777	39.62169
8	Liaoning	Linghai	121.52926	40.89220
9	Liaoning	Dawa	121.84894	40.94336
10	Liaoning	Panshan	121.58153	40.85648
11	Shandong	Wudi	118.03207	37.92738
12	Shandong	Kenli	119.05387	37.81526
13	Shanghai	Pudong	121.98047	30.88803
14	Shanghai	Chongming	121.96552	31.50342
15	Shanghai	Chongming	121.85482	31.33816
16	Tianjin	Binhaixinqu	117.71711	39.00951
17	Tianjin	Binhaixinqu	117.42913	38.66588