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

(UNDP/GEF YSLME Phase II Project)

# The map of priority areas for designation as conservation areas in YS and identify opportunities for improvements in connectivity with existing and new MPAs

2019.08.30

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# CONTENT

## executive summary

The Yellow Sea is a typical shelf marginal sea， meanwhile , the Yellow Sea Large Marine Ecosystem (YSLME) is one of the 66 Large Marine Ecosystems (LMEs) in the world. The Yellow Sea marine ecosystem and the services it provides are suffering from tremendous environmental pressures from coastal economic development and global change. For a long time, a large number of marine protected areas have been established inside and along the Yellow Sea to improve such conditions.

The connectivity of natural areas is a prerequisite for wildlife dispersal and survival and for the conservation of biodiversity in general. In this research, a calculable indice (PC) is used for connectivity analyses which can not only reflect the fragmentation of the protected area network and identify the negative patch, but also better measure the connectivity of the protected area, considering the diffusion process of the organism to comprehensively evaluate the ecological processes of various elements in the network from the perspective of function. The result is as follows: the connectivity value of the 27 marine protected areas in the Yellow Sea is between 0.000474 and 54.02775. The highest one is the Jiangsu Yancheng Wetland National Nature Reserve·Rare Birds with a connected importance value of 54.02775， while the connectivity of protected areas around the Shandong peninsula is generally low. On the whole, the patch area with a high value is large and evenly distributed

throughout the system. In the future, the marine protected areas in the marine functional zoning should be rationally laid out by studying the level of connectivity between the elements, and appropriate measures should be taken to manage large-area marine protected areas that play an important role in connectivity.

# 1. Preface

## 1.1 Background and introduction

There are 271 marine protected areas in China, including 160 marine nature reserves, 111 marine special protection zones. Among them, there are 106 state-level protected areas, 51 provincial-level protected areas, 47 municipal-level protected areas. and 67 county-level protected areas (National Forestry and Grassland Bureau, 2019).

The construction and management of the Yellow Sea Marine Reserve in China began in the 1980s. The "Changdao Nature Reserve" began construction in 1982 and was approved by the State Council as a national nature reserve on May 9, 1988. The "Jiangsu Yancheng Wetland National Nature Reserve, Rare Birds" was approved in 1983 by the People's Government of Jiangsu Province. It was established in October 1984 and was promoted to a national nature reserve by the State Council in 1992. In the same period, there were other protected areas established, such as the Sanggouwan County-level Protected Area, which was established on May 1, 1987, and the Qiansandao Provincial Nature Reserve, which was established on December 1, 1992. After nearly 10 years, the Yellow Sea did not have a new marine protected area in China.

After entering the 21st century, with the emphasis on marine protection in Shandong Province, six marine nature reserves were established in 2001-2004 to protect wild animals and marine coastal habitats.

In 2007-2009, the Ministry of Agriculture announced 11 national aquatic germplasm resources conservation areas in the Yellow Sea area in three batches, which promoted the establishment of protected areas for marine wild animals. In 2009-2011, with the management innovation in establishment of the National Ocean Special Protection Zone's, the Yellow Sea District has established more than 10 marine special protection zones, and the construction of the Yellow Sea Marine Reserve has entered a leap-forward development period.

In 2011, the State Oceanic Administration approved the construction of three national-level marine parks in Liugong Island, Rizhao city and Haizhou Bay in Lianyungang, Jiangsu. Since then, the coordinated development of marine protection and human life in the Yellow Sea has opened a new chapter in history (Zeng,2013).

## 1.2 Marine Protected Areas in YSLME

The coastal wetlands in the Yellow Sea region are on the migratory birds' East Asia-Western Australia migration route, with vast habitats and rich biodiversity. They are important stopping and breeding places on many endangered waterbird migration pathways. With the increasing prosperity of the coastal economy, marine development and utilization activities in the coastal areas of the Yellow Sea have become increasingly frequent, at the same time, great pressure has been placed on the ecosystems of the Yellow Sea.

In order to strengthen the protection of the Yellow Sea marine ecosystem, as of December 2018, there have been 31 national marine protection sites of various types in the Yellow Sea, with a total area of about 8,000 square kilometers, accounting for 3.38% of the total area of the Yellow Sea in China. Among them, there are 6 marine nature reserves with a total area of more than 5,500 square kilometers. The other 25 are special marine reserves, with a total area of nearly 2,500 square kilometers. The main protected target of these MPAs include endangered marine species, precious marine natural relics, typical marine ecosystem such as seagrass beds, islands, coastal wetland, estuaries and bays.

## 2. Project area and method

### 2.1 Project area overview

The Yellow Sea is a semi-enclosed shallow sea all located on the continental shelf. When the ancient Yellow River entered the sea in northern Jiangsu, it carried a large amount of sediment, making the water color yellowish brown, hence the name.

The Yellow Sea is connected to Liaoning province in the north, Shandong and Jiangsu province in the west, North Korea and South Korea in the east. It communicates with the Bohai Sea through the Bohai Strait in the northwest, and connects to the East China Sea in the south from the Qidongzui on the north bank of the Yangtze River estuary to the southwest corner of Jeju Island. Strait. The coastline starts from the Yalu River estuary in Liaoning and south to Qidongjiao in Jiangsu. The coastal areas include Dandong City to Lvshunkou District of Liaoning Province, Penglai City of Shandong Province (including Penglai City) to Rizhao City and all coastal areas of Jiangsu Province. It is customary to divide the Yellow Sea into two parts, the south and the north, with the boundary between the Chengshanjiao (Chengshantou) of the Shandong Peninsula and the Changshan (string) of the Korean Peninsula. The shape of the North Yellow Sea is approximately elliptical, and the South Yellow Sea can be roughly regarded as a hexagon. There are West Korea Bay in the northeastern part of the North Yellow Sea, Jiaozhou Bay and Haizhou Bay in the west of the South Yellow Sea, and Jianghua Bay on the east coast.

The area of the Yellow Sea is much larger than that of the Bohai Sea. Only the area of the North Yellow Sea is comparable to that of the Bohai Sea, which is 7. $13 \times 10^4$ $km^2$. The area of the South Yellow Sea is larger, about $30.9 \times 10^4$ $km^2$, which is more than three times larger than the Bohai Sea. The average depth of the North Yellow Sea is 38 m, the average depth of the South Yellow Sea is 46 m, and the average depth of the total Yellow Sea is 44 m. The deepest point is 140 m, located north of Jeju Island.

The type of the Yellow Sea coast is complex, along the Shandong Peninsula, the Liaodong Peninsula and the Korean Peninsula, most of them are bedrock gravel coasts or harbor-style sandy coasts. From the north coast of Jiangsu Province to the north of the Yangtze River estuary and near the mouth of the Yalu River, it is a silty muddy coast.

## 2.2 Objective of this report

The component 4 of YSLME Project Phase II addresses improving ecosystem carrying capacity with respect to supporting services. As stated in the Outcome 4.2 of Component 4 entitled “MPA network strengthened in the Yellow Sea”, the project will support a series of activities leading to the expansion of the MPA system that will take into account connectivity measures by use of developed connectivity toolkit or other means and increase in management effectiveness of existing MPAs.

In commensurate with the target of the project to increase MPA coverage taking into account connectivity and management effectiveness of MPAs, the project will map the priority areas for designation as conservation areas in YS and identify opportunities for improvements in connectivity with existing and new MPAs.

## 2.3 Data and methods

By dividing different marine functional type zones according to factors such as geographical location, natural resource conditions, natural environmental conditions and social needs, China has developed marine functional zoning to guide and constrain the practice of marine development and utilization to guarantee the economic, environmental and social benefits of offshore development. At the same time, marine functional zoning is the basis of marine management (Baidu Encyclopedia,2009), which also delineates and reserves a scope for marine protected areas. Therefore, the marine protected area planned in the marine functional zoning can be used as the priority area of the marine protected area, which obtained by digitizing the released marine functional zoning map, as shown in figure 2.1.

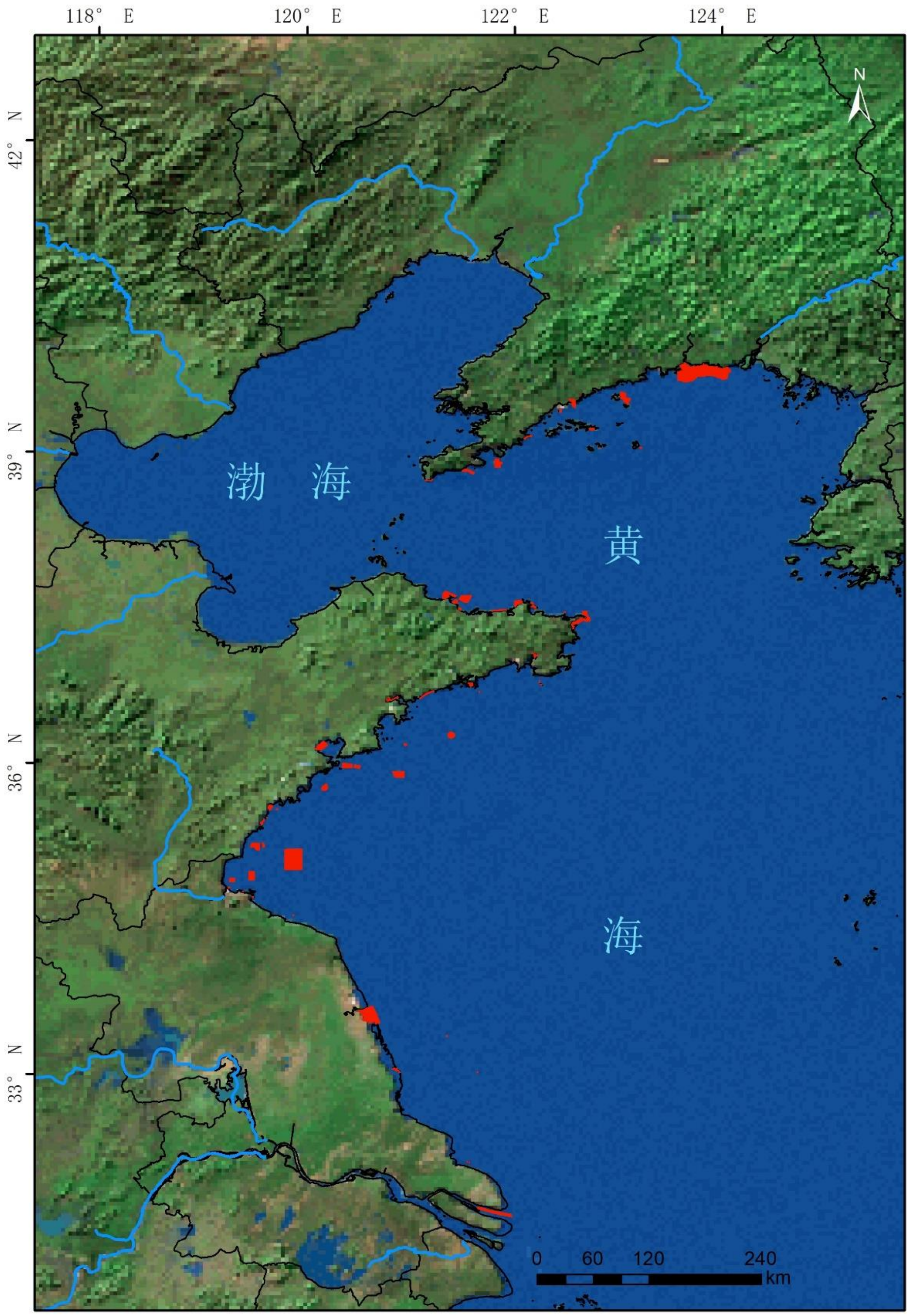


Figure 2.1 Priority area distribution of the Yellow Sea Marine Reserve

The existing protected area data used is the Yellow Sea Marine Protected Area data provided by the National Marine Data and

Information Service (NMDIS). The specific distribution is shown in figure 2.2.

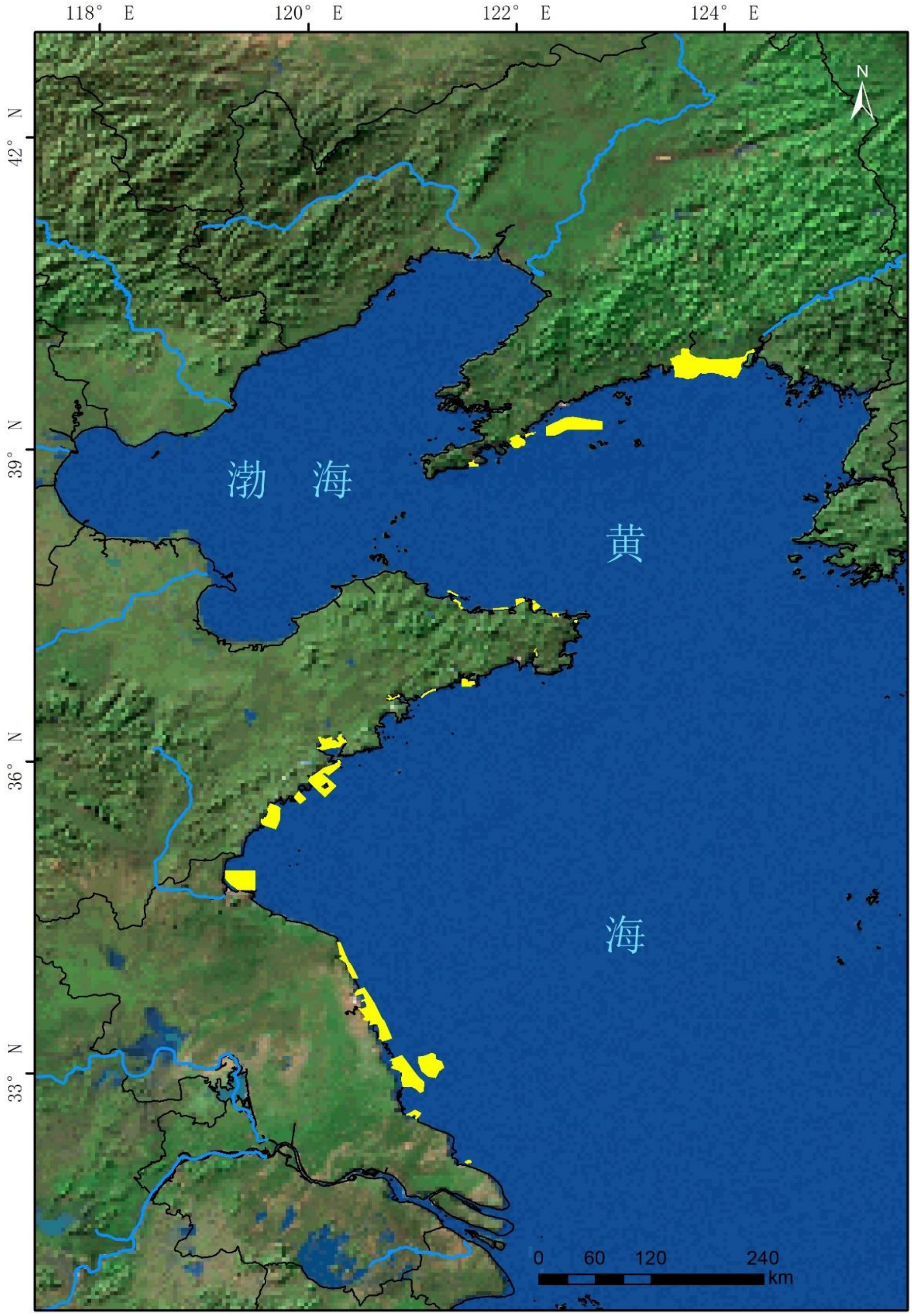


Figure 2.2 The existing protected area in the Yellow Sea

The connectivity index is diverse and can be divided into structural connectivity index and functional connectivity index (Wu, 2000). The structural connectivity index includes landscape pattern indices such as fragmentation, agglomeration, isolation, and connectivity index CI, which measures the apparent continuity of the landscape in space (Flather ＆ Sauer, 1996; Shumaker, 1996). The connectivity index (CI) of the landscape pattern index and the ecological connectivity index (ECI) based on the minimum cost distance are commonly used indices to evaluate the degree of landscape connectivity. The CI and ECI can not only reflect the relationship between landscape structure change and connectivity directly and indirectly, but also identify regions with important connectivity (Fu et al. ，2010). However, these two indices have some basic theoretical contradictions between the connection degree measurement under certain special landscape structure and landscape ecology, such as the degree of connectivity in a single plaque is highest, but the two index values are 0(Fu Wei et al., 2009). In view of the shortcomings of these two indices, Pascual-Hortal and Saura (2006) proposed the index Probability of Connectivity (PC) based on the view of habitat availability.

The method used is the PC, which can not only reflect the fragmentation of the protected area network and identify the negative patch, but also better measure the connectivity of the protected area, considering the diffusion process of the organism to comprehensively evaluate the ecological processes of various elements in the network from the perspective of function.

Calculated as follows:

$$PC = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} a_i \cdot a_j \cdot p_{ij}^{*}}{A_L^2} \qquad (2)$$

In the formula: n represents the total number of patches in the region; $a_i$ and $a_j$ represent the area of patch i and patch j, respectively; $P_{ij}^{*}$ represents the maximum probability of direct diffusion of species in patches i and j; $A_L$ represent the area of the entire region. $0<PC<1$, the PC index is based on the likelihood model, and the larger the PC, the greater the likelihood of connectivity between habitat patches.

Index calculation is in software Conefor Sensinode 2.2 (Saura, S. & J. Torné. 2009). The calculation of the index requires a distance threshold for the connection of habitat patches in the designated area (PascualHortal & Saura, 2007). Based on the relevant literature and the field survey, the distance threshold is set to 5000 meters according to the diffusion ability of the population, the possibility of connecting between patches is set to 0.5.

## 3. Results and analysis

After calculation, we get the connectivity of the 27 marine protected areas in the Yellow Sea, the value of which is between 0.000474 and 54.02775. The larger the value, the greater the possibility of connectivity between habitat patches. Combined with GIS software, the important value dPC of patch connectivity is divided into five levels, and the distribution map of important patches of connectivity is obtained, as shown in figure 3.1.

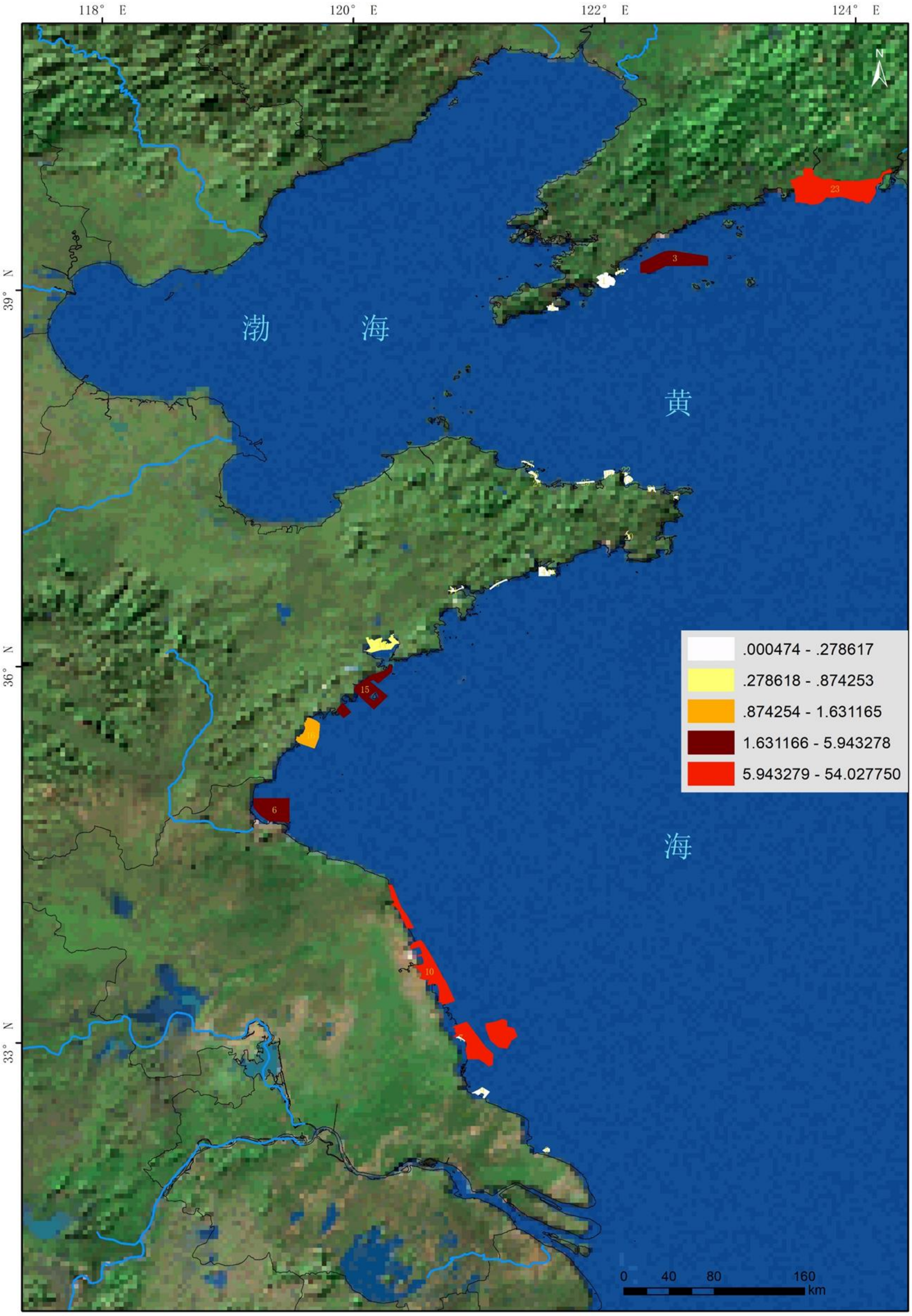


Figure 3.1 Distribution map of important value patches in connectivity of the Yellow Sea marine protected area

It can be seen that the patch area with a high value is large and evenly distributed throughout the system. The highest one is the Jiangsu Yancheng Wetland National Nature Reserve · Rare Birds with a connected importance value of 54.02775, which is composed of four red areas in the picture. It is worth noting that the connectivity of protected areas around the Shandong peninsula is generally low (0.000474~0.6081). One of the reasons is that the area of the protected areas is relatively small, only between 447.69 to 4831.99 hectares, the largest of which is the Darushan national marine park, the smallest is the Rongcheng whooper swan national nature reserve. Another reason is as shown in the figure, some protected areas located at the junction of the Bohai Sea and the Yellow Sea, such as Long Island and Penglai city, are assigned to the data set of the Bohai Marine Reserve. Therefore, they are not involved in the connectivity calculation. It also explains why several protected areas around the Liaodong Peninsula (such as Dalian Jinshitan National Marine Park, with an area of 11095.78 hectares) still less connected in spite of larger in area.

## 4. Conclusion

Therefore, the marine protected areas in the marine functional zoning should be rationally laid out by studying the level of connectivity between the elements in the future, and appropriate measures should be taken to manage large-area marine protected areas that play an important role in connectivity.

Although in principle the establishment of a larger area of priority area can improve its connectivity, the contradiction between the need for marine development and the protection of marine ecology has become increasingly fierce, making this possibility limited. And from table 4.1, it can be seen that most of the protected area connectivity values involved in the calculation are located in the lowest level interval, so our conservative suggested area for the priority areas in the future is the threshold with the next lowest level of connectivity value in this study (the bold area in the table), about 10000ha, which will not only help maintain good connectivity in the priority area, but also not re-intensify the conflict between sea use and protection.

Table 4.1 Comparison of area and PC value of each protected area in the Yellow Sea

| **ID** | **Area（ha）** | **dPC** |
|---|---|---|
| 1 | 11095.78 | 0.278617 |
| 2 | 2542.32 | 0.014206 |
| 3 | 52499.50 | 5.943278 |

| | | |
|---|---|---|
| 4 | 4831.99 | 0.060810 |
| 5 | 1476.15 | 0.005108 |
| 6 | 47120.52 | 4.784477 |
| 7 | 1045.30 | 0.012472 |
| 8 | 1222.98 | 0.003224 |
| 9 | 4695.86 | 0.047582 |
| 10 | 158333.44 | 54.027750 |
| 11 | 1222.76 | 0.003335 |
| 12 | 1279.71 | 0.015527 |
| 13 | 3234.99 | 0.042990 |
| 14 | 20020.46 | 0.874253 |
| 15 | 46717.01 | 4.715504 |
| 16 | 27492.39 | 1.631165 |
| 17 | 447.69 | 0.000675 |
| 18 | 1096.84 | 0.012840 |
| 19 | 3062.50 | 0.029751 |
| 20 | 459.89 | 0.000474 |
| 21 | 1348.57 | 0.006130 |
| 22 | 1179.56 | 0.018552 |
| 23 | 113034.48 | 27.530360 |
| 24 | 581.44 | 0.002277 |
| 25 | 1510.44 | 0.007118 |
| 26 | 1249.31 | 0.005711 |
| 27 | 770.00 | 0.002457 |

As can be seen from figure 4.1, a large number of priority areas have been newly delineated around the Shandong Peninsula area where connectivity is relatively low, and the Liaoning sea area secondly, which will improve the connectivity of these areas. In the Jiangsu sea area with relatively high connectivity, there is no layout of the larger priority area of the marine protected area.

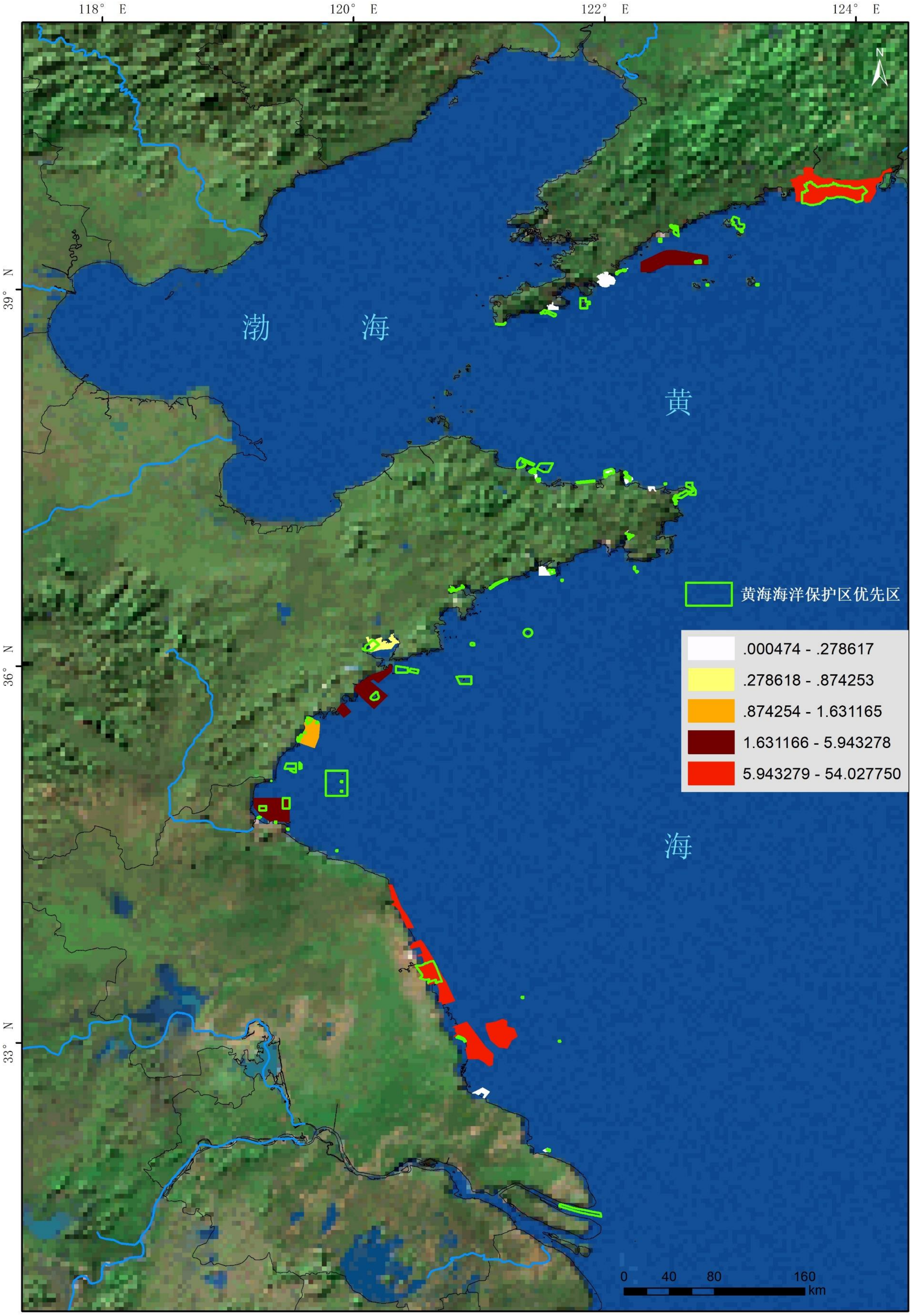


Figure 4.1 Priority areas overlaps with protected area connectivity

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| LMEs | Large Marine Ecosystems |
| PC | Probability of Connectivity |
| MPA | Marine Protected Area |
| NMDIS | National Marine Data and Information Service |
| CI | Connectivity Index |
| ECI | Ecological Connectivity Index |