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Research on Marine Functional Zoning of Dingzi Bay based on Resources and Environmental Evolution

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Abstract

As a result of rapid growth in reclamation for aquaculture and salt industry driven by economics, the sea area and water quality in Dingzi Bay were significantly reduced, leading to apparent decrease in benefits of aquaculture and salt industries, the severe loss of coastal wetland as well as the reduction of biodiversity due to large-scale reclamation. The water quality in Dingzi Bay was found to fall below the standard of second kind level in accordance with <Marine Functional Zoning of Shandong Province> (2004)(In marine functional zoning of China, the sea water quality is divided into four kinds standard. The sea water quality which is lower than the second kind level cannot be used for aquaculture and salt production). According to the <Marine Functional Zoning of Shandong Province> (2004), aquaculture and salt industry are the two leading industries in Dingzi Bay, but at present the water quality in Dingzi Bay was not suitable for aquaculture and salt industry development, and the aquaculture and salt industry were incompatible with the needs of marine economy sustainable development and marine environmental protection. Nevertheless, the profound cultural background and Location advantage of Dingzi Bay was not fully developed. Therefore, the remediation and restoration of Dingzi Bay were urgently needed to improve regional environmental, optimize the coastal industrial structure, make good use of cultural tourism resources, and enhance regional economic and social development, the goal of which is to construct the marine culture tourism industry cluster district in Dingzi Bay. Based on dramatic changes in resources and environment in Dingzi Bay and unsuitability for current aquaculture and

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salt industry development, so it is suggested that the marine functional zoning in Dingzi Bay in <Marine Functional Zoning of Shandong Province> (2004) should be modified in order to restore the marine environment and promote regional economic development.

Keywords: Dingzi Bay, marine function zoning, resources and environment

1. Introduction

1.1 Location

Dingzi Bay, located at 120° 44' ~ 120° 58'E, 36° 32' ~ 36° 40'N, is surrounded by Jimo, Laiyang and Haiyang Cities and next to the Yellow Sea. As a semi-enclosed inner bay, it is characterized by the complex coastlines. The name of "Dingzi" comes from the fact that its shape is like the Chinese character '丁'. Its nearby villages and towns include Jinkou, Fengcheng, Wangcun, Tianheng, Xuefang, Yangjun, Xingcun and Xinan.

1.2 History overview

Dingzi Bay was an important military fort in the Ming Dynasty in the past, in order to prevent pirate intrusions and its military importance reached its peak in the years of Emperor Qianlong of Qing dynasty. Besides it was also highlighted as a famous commercial harbor, namely Jinkou harbor. However, such functions were largely weakened from the beginning of the 19th century due to severe sediment deposition, as a result of which, the utilities of transport has been completely discarded now.

1.3 Natural conditions

In early 1970s, Dingzi Bay was once about 22km length, about 12.3km width, with its mouth width of about 2.8km. Most of the Dingzi Bay is shallower less than 5 m except in the vicinity of Kaolaotou, where the water depth is deeper, than 20m. As a consequence of massive reclamation driven by aquaculture development and salt industry, however, the tidal capacity and area of Dingzi Bay was significantly reduced. For instance, in 2010 the cover area of Dingzi Bay was only about 176.6km^2 and the shoreline width that water could reach naturally was only about 11.2km, with a tidal water capacity area of about 72.6km^2.

1.4 Marine functional zoning in China

The marine functional zoning can be regarded as the extension and development of land use planning seaward in China. At present, there is not such a large-scale and systematic division of marine functional zones worldwide as in China. Its concept is as following: based on locations, natural resources and environmental conditions, considering the current status of marine development and utilization and socio-economic development

needs or other factors, sea water can be divided into different types of functional zones by the marine function standards in order to determine the most appropriate marine function sequence for controlling and directing the sea use and to provide scientific basis for rational sea use and marine environmental protection. The objective of marine functional zoning is that according to the marine natural attributes, combined with social needs, the main functions of coastal zones and their sequence can be determined. It can provide basis for marine development and protection as well as overall guidance for a sustainable development and marine protection.

2. Present situation

2.1 Abuse of sea and beach

Currently, the primary usage of sea and beach are taken for shrimp ponds and salt industries in Dingzi Bay (see Table 2-1), which account for approximate 57.81% of the cover area of the bay, equivalent to about 102.1km^2, which result in that the area of total tidal water capacity is nearly 72.6km^2.

2.2 Severe siltation

As the sequence of significant reclamation for aquaculture development and salt industry, the covering area as well as the water body is greatly reduced, leading to a slowdown of tidal inflows, disability of sand-carrying, as well as severe siltation, thus severe ecological disasters are caused by such changes. For instance, the topography nearby Xiang island(Flowers island), which lies around the Five Dragons River estuary west of the embayment, is so shallower that one can reach this island on foot when ebb tides due to sediments deposition. Yanju fishing port, which located off Laiyang City, was once a good harbor for fishery ships less than 30 years ago and now degraded to a intertidal zone as the result of severe siltation.

2.3 Recessions of salt industry

The primary salt production field in Dingzi Bay lies inside the Haiyang, which includes three salt fields in 1988 with the average production of 9894.7t/km^2. However, now the vegetation recession, coastal reclamation as well as the engineering construction almost destroys the salt industry in Dingzi Bay. According to statistics, only two salt yields remains by the end of 2010 and the salt production has dropped from 9894.7t/km^2(in 1988) to 2329.0t/km^2.

2.4 Slow development of aquaculture

As one of the important industries developed in Dingzi Bay, the unit production of aquaculture decreases apparently, with the increase of area usage in the past 2 years. One evidence is that the total values of aquaculture industry grow slowly although the rapid rising of seafood price in recent years.

2.5 Rapid development of tourism

A rapid development of tourism has been made in recent years along Dingzi Bay. One evident is that the number of employees in tourism rises from 335 million in 2005 to 3.7 million in 2009, much higher than that in fisheries (less than 1 million). Besides, the output value of the tourism also has reached 32 billion yuan in 2009, increasing nearly 3.64 times in recent 5 years.

2.6 Problems

The primary problems of sea use and marine environment in Dingzi Bay can be summarized as following: the abuse of coastal reclamation for aquaculture and salt industry leaded to significant decrease of tidal water capacity in Dingzi Bay; large-scale reclamation near Wulong River estuary also resulted in siltation, especially in the top of Dingzi Bay. Large wetland was lost due to the rapid growth of aquaculture and salt ponds construction. Because of aquaculture sewage and weak hydrodynamic condition, the sea water quality declined for years. Aquaculture and salt industry are still using the traditional methods. The third industry was not developed. The marine cultural heritage and natural resources are not fully utilized and marine culture tourism industry cluster has not been established in Dingzi Bay.

3. Resources and environmental changes

3.1 Eco-environmental changes

3.1.1 Water Quality Environment

The historical sea water quality survey in 1989, 2007, 2009, 2010 [3][4][5] has pointed out that sea water quality in Dingzi Bay was worsening year by year. In 1989 only inorganic phosphorus fall short of the sea water quality requirements, while inorganic nitrogen,

petroleum and heavy metals Zn also fall short of the sea water quality requirements in several stations in 2007. The concentration of heavy metals and pH were found to exceed the sea water quality standard in 2009 and 2010. Compared with the historical sea water quality survey data in Dingzi Bay, it can be found that the concentration of Zn was declining, while the concentration of petroleum and inorganic nitrogen increased slightly in the past three years. That indicated that sewage from aquaculture and small fishing boats could be the major sources of pollution in recent years, and the salinity increase was mainly caused by runoff decrease.

3.1.2 Biodiversity

It is shown that in T-Bay, where the dominant species are found to be Calanus sinicus strong arrow worms, the density of Calanus sinicus was 1 ~ 39ind/m^3 in Winter of 1982 (February) 10 ~ 22ind/m^3 in autumn (November) of 1982, 40ind/m^3 in Spring (April) of 2007, only reaching the similar level in winter of 1982 and showing a decreased trend; Density of strong arrow worms was found to be 76 ~ 139ind/m^3 in Winter of 1982 (February), 26 ~ 67ind/m^3 in autumn (November) of 2007, 16.6ind/m^3 in spring (April) of 2007as, lower than that in both autumn and winter in 1982. Therefore, the density of two dominant species in Dingzi Bay was found to be decreased in 2007 comparing with 1982. The structure of phytoplankton species in 2010 remains similar with that in 2007.

In 1982, 16 kinds of fish eggs and larval fish were found in Dingzi Bay, including mackerel, mullet, barracuda, black sea bream, sea bass and other commercial fish. However, only 12 kinds of fish, plankton (class), were found in the survey of Dingzi Bay in 2004 without any major economic species, showing a decrease relative to 1982. Comparing with results of intertidal zones from 2007 to the spring of 2008, the average biomass of benthic organisms decreased significantly from 70.19g/m^2 to 10.3g/m^2 in 2010. Besides the benthic species structure in T-Bay also changes considerably in 2009 comparing with that in 2007, including significant drop in the number of species, a lower proportions for both polychaetes and mollusks and a higher ratio for crustaceans. The data about cavity sausages, New York shaped, echinoderms, and fisheries resources were not included in this survey. A declining trend for the benthic species diversity in Dingzi Bay can be summarized from above analysis.

3.1.3 Tidal water capacity

Two cases were designed by a numerical simulation model through DHI hydrodynamic simulation software to test the tidal water capacity importance in Dingzi Bay as following. Case one was designed to simulate the tidal water capacity with the current coastline including ponds, and case two was designed to simulate the tidal water capacity with the original coastline excluding the current ponds. The topography and coastline used in the model was derived from nautical charts by the Ministry of People's Liberation Army Navy and satellite remote sensing images. Four primary tidal constituents,

namely M_2, S_2, K_1 and O_1, extracted from two tidal observation stations, were added to provide astronomical tides through the open boundary. The tides and tidal currents were validated with several in-situ observations. The simulation results show a good agreement between the model and observations.

The total tidal water capacity in Dingzi Bay was calculation during spring tidal, i.e. total tidal water capacity = water body volume + accumulated flood tidal volume. The results show that, the total tidal water capacity was $2.98\times10^8m^3$ during spring tidal and $2.76 \times 10^8m^3$ during neap tidal in case one. However, the total tidal water capacity was increased to $4.7\times10^8m^3$ during spring tidal and $4.32\times10^8m^3$ during neap tidal without ponds, reaching up to about $1.72\times10^8m^3$ during spring tidal and $1.56\times10^8m^3$ during neap tidal without ponds than at present. Therefore, the total ti0dal water capacity in Dingzi Bay can be greatly enhanced by the removal of the existing ponds for aquaculture and salt production, which is also helpful to improve sea water quality due to better diffusion conditions without ponds.

3.1.4 Water exchange rate

The water exchange rate was also simulated in the above two cases. It was shown that water exchange rate will increase linearly over time and the lowest values of water exchange rate mostly can be found at the top of the Dingzi Bay due to shallower water depth and weak current velocity, especially along the coast of Laiyang and Jimo, which may be caused by the weaker current velocity associated with the massive intertidal zones. Water exchange rate was significantly greater during spring tidal in case two than case one because of larger sea area in case two. For an instance, only one tidal cycle was required to reaches up to 65.9% for the average water exchange rate in case two, while 13(during spring tidal) and 10(during neap tidal) cycles were requried to reach only 50% in case one, which showed the water exchange rate in case one was much lower. Thus it was concluded that reclamation large number of ponds occupied wetlands and intertidal zones can easily influence the water exchange rate. Moreover, lower water exchange rate also resulted in pollutants dilution reduction.

Therefore, it can be seen that severe environmental problems were caused by ponds for aquiculture and salt production in Dingzi Bay. First, severe siltation, caused a greater decrease in the area associated with total tidal water capacity, from $174.7km^2$ (excluding islands and sea area occupied by ponds for aquiculture and salt production) to $72.6km^2$ currently, leading to 58% losses of covering sea area, which consequently influence the hydrodynamic environments and especially weaken the flow around main tidal channels, such as nearby the mouth of Wulong River (at the top of the Dingzi Bay). The weaker current velocity further exacerbated sedimentation. The total tidal water capacity was reduced by about 50% and water exchange rate by about 25%-53% after reclamation for ponds. Besides, the ability of self-purification was also declined, all of which in turn

exacerbate the sea water quality decline in Dingzi Bay.

3.2 Wetland loss

Since the aquaculture and salt industry were developed in Dingzi Bay, the intensity of development and utilization of coastal zone became larger. Large intertidal zones and supratidal zones were replaced by artificial wetlands, such as shrimp ponds and salt fields and so on. The original wetland landscape has been divided to many relatively independent smaller patches, such as aquaculture ponds, salt fields, harbors, roads, dams and canals, and the number and density of wetland patches also increased greatly year by year. Coastal wetland fragmentation was mainly manifested as high landscape patch density index. According to statistics, the number of landscape patches was about totally 4540ind, and landscape patch density index was about 44.5ind/km^2, which showed a increasing trend of wetland landscape fragmentation in Dingzi Bay. Secondly, coastal wetland landscape fragmentation was also reflected by the increase of dams, roads and artificial corridor, which blocked the material and energy exchange among wetland and also increased human interferences on coastal wetlands. Based on the entire view of landscape layout in Dingzi Bay, there was most severe fragmentation in intertidal zone and supratidal zone, in which fragmentation density was higher than in subtidal zone. Therefore, the construction of shrimp ponds and salt fields play an important relationship in wetland landscape fragmentation in Dingzi Bay, which indicated that wetland landscape fragmentation was closely related to human disturbance activities.

4. Suitability of marine functional zoning in Dingzi Bay

According to <Marine Functional Zoning of Shandong Province> (2004) (Figure 4-1), agricultural zones, beach aquaculture zones, shallow sea aquaculture zones, proliferative zones, salt fields zones, coastal protection forest zones and pollution prevention zones were the main marine functions[6]. Considering poor living of the surrounding residents and good water quality and light condition in 1990s, aquaculture and salt industry were developed in Dingzi Bay to promote economic development. Thus, the main marine functional zones in Dingzi Bay are mainly dominated by traditional agriculture according to <Marine Functional Zoning of Shandong Province> (2004). However, at present, there was great changes in natural and social conditions in Dingzi Bay, so any plan should be implemented under new situations.

4.1 Implementation of the current marine functional zoning in Dingzi Bay

4.1.1 Good spatial consistency

Currently, the sea use pattern in Dingzi Bay was basically consistent with marine functional zoning in <Marine Functional Zoning of Shandong Province> (2004). Most of the sea and beach were occupied by shrimp ponds and beach culture, only several salt fields existing along Laiyang and Laiyang coast.

4.1.2 Marine environment quality over standard in partial sea areas

Due to large-scale coastal reclamation inducing reduction of the area of tidal waters capacity, there was a sharp decline in total tidal water capacity by 50% compared to before reclamation through numerical model results. Data from seawater quality survey in 2010 showed that majority of seawater quality in Dingzi Bay reach seawater quality standards class two[5]. However, there were some indicators from some stations exceeded the standard, such as heavy metals Cd and Cu. It was also founded that zooplankton density and biodiversity decreased significantly. According to the current <Marine Functional Zoning of Shandong Province> (2004), aquaculture and salt industry were the main sea use pattern in Dingzi Bay, and the corresponding seawater quality standard was required class one for aquaculture along Jimo coast, class two for aquaculture and salt industry along Haiyang and Laiyang coast. Based on <Marine Environment Quality Bulletin of Shandong Province in 2010>[7], seawater quality in 2010 can basically satisfy the requirements of the current <Marine Functional Zoning of Shandong Province> (2004). However, based on recent (2007-2009) seawater quality survey results, seawater quality was generally reach seawater quality standard class two, and results from several stations reach class three. Thus seawater quality in Dingzi Bay cannot fully consistent with the requirements of <Marine Functional Zoning of Shandong Province> (2004).

4.1.3 Current marine functional zoning's impacts on sustainable development in Dingzi Bay

According to the data statistics about marine economy along coast and natural resources changes, it was found that the increase in aquaculture output value depended on aquaculture areas expansion, lack of scientific aquaculture and factory farming. Secondly, there was a greatly decline in salt output per square kilometer, which resulted in that many salt fields were transformed to aquaculture ponds. The only remaining three salt fields can explain this phenomenon. Moreover, the total tidal water capacity was very small presently, and seawater quality of partial area exceeded seawater quality standard class two. Thus, the present marine functional zoning in Dingzi Bay basically supported the development of aquaculture and salt industry, but it did not make full use of its marine

cultural tourism resource advantages, and the marine environment should be improved urgently. Therefore, the present marine functional zoning based on aquaculture and salt industry was no longer consistent with the sustainable development in Dingzi Bay.

5. Necessity for marine functional zoning modification in Dingzi Bay

5.1 The need for the implementation of the Blue Shandong Peninsula Economic Zone's development strategy

The blue economy includes marine resources and marine space development, as well as directly or indirectly related service industries. The integration of marine and land together is a notable feature for blue economy in China. The Blue Shandong Peninsula Economic Zone space layout fully embodies the concept of integration of marine and land. <Blue Shandong Peninsula Economic Zone Development Plan> was an important plan of economic development in the next 10 years. In order to provide a strong space and resource protection for blue economy, various types of marine development activities should be integrated and coordinated by marine functional zoning through marine space resources optimization, marine economy structure adjustment and promoting scientific marine resources development. According to the <Blue Shandong Peninsula Economic Zone Development Plan> approved by the State Council early in 2011, Dingzi Bay was considered as a cultural tourism industry cluster district, which will focus on the centralized development of culture and entertainment, marine sports, marine science and technology and other cultural services. There is a significant geographical location advantage of Dingzi Bay, which is in the following intersection zones, such as northeast Asia economic circle, Yellow Sea and Bohai economic circle, Yellow Sea economic belt, Shandong Peninsula city groups and advanced industrial belt. The development and construction of Dingzi Bay marine cultural tourism industry cluster district, will not only help expand investment, stimulate domestic demand and maintain growth, promote urban development, increase employment, improve life quality along Dingzi Bay coast, will help accelerate development mode change, improve the quality and efficiency of economic growth, not also will help expand the breadth and depth of opening, participate in international cooperation and competition at a higher level and a wider field.

Dingzi Bay is located between Qingdao and Yantai, which is a new bright spot in the integrated development of the Shandong Peninsula in the plan of Blue Shandong Peninsula Economic Zone. The construction of marine culture tourism industry cluster

district in Dingzi Bay will not only harmonize the coastal industry layout, but also promote the dislocation development. Thus, based on the actual situation of resources and environment in Dingzi Bay, the construction of marine culture tourism industry cluster district and marine environmental remediation should be implemented simultaneously.

5.2 The need for scientific use of sea and land-and-sea integrated development

The <Blue Shandong Peninsula Economic Zone Development Plan> highlights scientific use of sea and economic development mode transition, emphasizes marine economic structure optimization, strengthens the construction of marine ecological civilization, improves marine science and education support ability and innovate coastal zone management mechanism.

5.2.1 The need for the change of sea use pattern

Currently, marine economic structure in Dingzi Bay is very simple. Take marine products for an example, its efficiency of resource use is low with very low added value. Moreover, significant loss of sea and wetland, destruction of coastline and severe sedimentation brought many difficulties for suitable development. Therefore, the existing sea use pattern must be changed. According to the latest <Centralized and Intensive Sea Use Plan in Blue Shandong Peninsula Economic Zone>, it emphasizes a new sea use mode for Dingzi Bay based on resource-saving and environment-friendly. It pointed out that on the basis of marine ecological environment preservation, the greatest ecological, economic and social benefits can be gained through the change of sea use pattern, the change of marine economic structure and centralized and moderate scale development at the cost of minimum shoreline and water occupied.

5.2.2 The need for orientation of marine cultural tourism industry

Coastal reclamation in Dingzi Bay resulted in severe sedimentation, decline in tidal water capacity, wetland resources loss, reduction of salt production and fishery and so on. So the current resource and environment can no longer support suitable development of salt and fishery industry. However, Dingzi Bay has a deep historical and culture of grangeur, such as abundant wetland resources and multiple coastal landforms, coupled with the advantage of geographical location, which lay a good foundation for the construction of marine cultural tourism industry cluster district. Cultural tourism industry is one of the styles of eco-friendly tourism; it would pay attention to the ecological, economic and cultural tourism process. Based on the good environment and deep historical culture, Dingzhi Bay marine cultural tourism would be helpful both in environment protection and economic development.

5.2.3 The new requirements of land-and-sea integrated development

Land-and-sea integrated is the most effective way to increase hinterland economic development with rich marine resource. Dingzi Bay is located in the intersection area among Qingdao, Yantai and Weihai. As we known, there were much economic exchanges and cooperation between Qingdao, Yantai, Weihai and other cities from Bohai economic belt, where located the major cities in social, economic and tourism cooperation with Japan and South Korea. Secondly, according to <Shandong Peninsula Urban Agglomeration General Plan> (2006-2020) [8], four development axis were as following. Jinan-Zibo - Weifang - Qingdao, and Rizhao-Qingdao -Weihai-Yantai were regarded as two main development axis. Yantai- Longkou - Laizhou - Weifang, Rizhao − Wulian − Zhucheng − Anqiu − Weifang − Shouguang - Dongying were regarded as two secondary development axis. The construction of marine cultural tourism industry cluster district is an important part of development axises. Therefore, it will further improve infrastructure overall construction and production factor overall configuration for the construction of marine cultural tourism industry cluster district in Dingzi Bay.

5.3 The need for the environmental improvement and industrial structure upgrade

Although Dingzi Bay has a good basis for marine cultural tourism industry development with location advantage and profound cultural background, the current marine functional zoning was dominated by aquaculture and salt industry in Dingzi Bay. So that its profound cultural details was not fully made use of to develop marine tourism industry. At present, marine industrial structure was unreasonable in Dingzi Bay, such as simple marine economy structure and backward development of tertiary industry, specifically as follows:

5.3.1 Large environmental pressure in coastal waters

Due to severe sedimentation in Dingzi Bay, it would lead to extinction without marine environmental integrated renovation. The current marine industry was mainly depended on extensive economic growth pattern and marine environmental degradation, such as natural coastline reduction, wetland deterioration and high excess rate of seawater quality, which resulted in obvious contradiction between economic and social development and resources and environmental carrying capacity. Thus, it greatly reflected sustainable development between marine ecological environment and marine economy.

5.3.2 Low level of marine industrial structure

At present, the pattern of marine resources development and utilization was too simple in Dingzi Bay, mainly based on traditional aquaculture and salt industry. What's more, there was no hi-tech industry. Therefore, low level of marine resource development and utilization resulted in inefficient use of marine resources and lack of high value-added marine products.

5.3.3 Backward economic growth pattern

One leading industry in Dingzi Bay, aquaculture, its annual aquaculture production value increased slowly year by year depend on aquaculture area expansion and aquaculture density increase. Another leading industry, salt industry, its annual output was shrinking year by year. Therefore, the reason why marine economic growth was too slow in Dingzi Bay is that extensive and low efficiency growth style. Moreover, if Dingzi Bay continues to develop as the current marine economic pattern, it will confront with the pricking up stress of marine resource reduction and marine environmental deterioration.

Whether considering marine ecological environmental protection or simple marine economic structure along coast, or function orientation from <Blue Shandong Peninsula Economic Zone Development Plan>, the current marine functional zoning based on aquaculture and salt industry, did not meet the needs of the development of new national economy in Dingzi Bay. The current marine functional zoning of Dingzi Bay should be modified in order to accord with the requirements of marine industrial structure optimization, adjustment and marine environmental protection.

5.4 Cultural and tourism resources conditions have already possessed

The proportion of output value from tourism industry in our national economy is continuing to increase. In most regions of China, tourism has become a pillar industry, superior industry and guide industry for promoting economic development.

5.4.1 The innate advantage of the development of tourism

Dingzi Bay is a shallow bay with comfortable climate. There are two islands in it, respectively named Sanping Island and White horse Island. Especially its beach is very suitable for tourism development, including a series of long coastal shoals. More importantly, the tourists are easily attracted by its abundant historical cultural details.

There are abundant tourism resources surrounding Dingzi Bay as follows (Figure 6-1), together with convenient railways and highways, which form a perfect tourism line. Ten-thousand-meters long beach, sand sculpture scenic spot, Mountain Zhaohu national

forest park, Congma Temple and the Red Cherry folklore scenic spot in Haiyang are in the north of Dingzi Bay. Hot spring scenic spot and Tianheng Island scenic spot in Jimo are in the south of Dingzi Bay. Gold Mountain beach tourist resort, Mazu Temple and Jinshan Tower and other historic sites are in the west of it. In addition, with the improvement of traffic condition as well as the formation of "Half Day Circle" along Shandong Peninsula coast in the future, it will bring more development opportunities and tourism source (Figure 6-2). The construction of marine cultural tourism industry cluster district will further promote the process of integration of Qingdao, Yantai and Weihai in Shandong Peninsula, and also become a new important bright spot in regional tourism soon.

5.4.2 The rigidity of tourism demand growth and great potential demand for tourism market in Dingzi Bay

At present, national income per capita was rising from $3,000 to $5,000 in China (National income per capita from Jimo, Haiyang, Laiyang along Dingzi Bay was respectively about $11,000, $5,800 and $4,200.). The rising income made more and more people had the ability for tourism consumption, which provided a superexcellent basis for tourism industry development. When people had adequate food and clothing, especially with the available idle money, the life style will be greatly changed including consumption. Tourism consumption increase was an outstanding performance. Moreover, in recent years, with the great change of urban residents' consumption concept in China, people are willing to spend money on travel and leisure. People in other cities around Dingzi Bay have rich life, which has laid a good foundation for the further development of cultural tourism resources.

5.4.3 Advices on tourism development in Dingzi Bay

Depend on beautiful natural landscapes and Human Landscape, the coastal tourism compound industry will be constructed on the south coast of Dingzi bay, including ecological processing, ecological technology, cultural creative and efficient aquaculture. More specifically, taken Fengcheng Town as the centre, strengthening the culture of the ancient city, the cultural and creative industry and vocation industry will be developed. The development of marine ecological agriculture, clothing industry, ecological technology research and development, diverse coastal tourism and leisure, marine park, high-end business vacation and ecological leisure and vacation. In the north coast of Dingzi Bay, taken Xuefang and Yangjun as centres, depend on mountain, forest and wetland in Xiang Island and Wulong river estuary, coastal tourism park will be developed.

5.4.4 Advices on compensation for aquaculture and salt industry in Dingzi Bay

At present, the residents around Dingzi Bay mainly lived on aquaculture and salt industry. But the current traditional aquaculture and salt pond were harmful for water quality protection in Dingzi Bay, and the construction of Dingzi Bay marine cultural tourism industry cluster district cannot benefit from it. When Dingzi Bay marine cultural tourism industry cluster district begin to carry out, most aquaculture and salt ponds will be removed. Thus, the local governments need to make relevant policies for compensation on aquaculture and salt ponds owners, and ensure that each owner receives compensation. Move over, the local governments should also make relevant policies to fishermen, such as supplying more jobs.

6. Conclusions

Dingzi Bay, located between Qingdao and Yantai, due to good geographical location and good social and economic conditions, was located as one of the nine Blue Shandong Peninsula Economic Zones, as marine cultural tourism industry cluster district. According to the current <Marine Functional zoning of Shandong Province> (2004), the basic function of sea use was fisheries and sea salt in Dingzi Bay, lack of high-end industry of marine functional zones, such as tourism and so on. Correspondingly, the present sea area development and utilization patterns of Dingzi Bay were mainly aquaculture and salt industry.

Currently, the marine ecological environmental is facing severe environmental pressures. Rapid economic and social development along Dingzi Bay, because of severe sedimentation and disordered dam constructions and reclamation and other factors, there were a sharp decline in total tidal water capacity and self-purification capacity. Moreover, the marine resource utilization efficiency was very low regarding traditional aquaculture and sea salt as the main marine function zoning. It was not helpful to take advantage of its location and cultural tourism resources. Especially in early 2011, after <Blue Shandong Peninsula Economic Zone Development Plan> became national development strategy, location advantage of Dingzi Bay is significant and its functional location will take place tremendous change. A reasonable plan for marine economy development based on resources and environment sustainable development and the overall plan of Blue Shandong Peninsula Economic Zone must be made. Therefore, the current marine functional zoning of Dingzi Bay is no longer suitable for the construction of blue economic zones and sustainable development. The conclusions are as follows through assessing socio-economic, resources and environment changes.

(1) Dingzi Bay and the surrounding areas have rich cultural heritage and tourism

resources, which lay a foundation for the development of cultural tourism industry. Moreover, the output of traditional fishing and salt industries were gradually decreasing with low efficiency of sea use, which should be optimized and upgraded as soon as possible. Therefore, the basic marine function in Dingzi Bay from the current marine functional zoning should be repositioned.

(2) In order to avoid the existing owner of aquaculture and salt ponds may strongly resist the remove of aquaculture area, ecological compensation mechanisms should be build. The following work would be needed: first, establish the legal framework of ecological compensation mechanism; second, definite compensation standard. This should be formulated by the local government according to the actual situation.

(3) There was a sharp decline in sea area, tidal water capacity and self-purification capacity due to coastal reclamation. In addition to severe siltation and seawater quality deterioration, the marine environmental quality cannot satisfy with the requirements of the regional marine functional zoning. Thus, remediation and restoration in Dingzi Bay are very necessary for improving its ecosystem services and resources and environment carrying capacity.

(4) It is suggested that the marine functional zoning in Dingzi Bay should be modified as following, industrial layout optimization along coast, high-end cultural tourism industry development and recreational fishery development.

In summary, marine environment and natural resources in Dingzi Bay have changed significantly, the current marine functional zoning should be modified in order to further integrate land and sea of economic and social development and optimize regional industrial structure.

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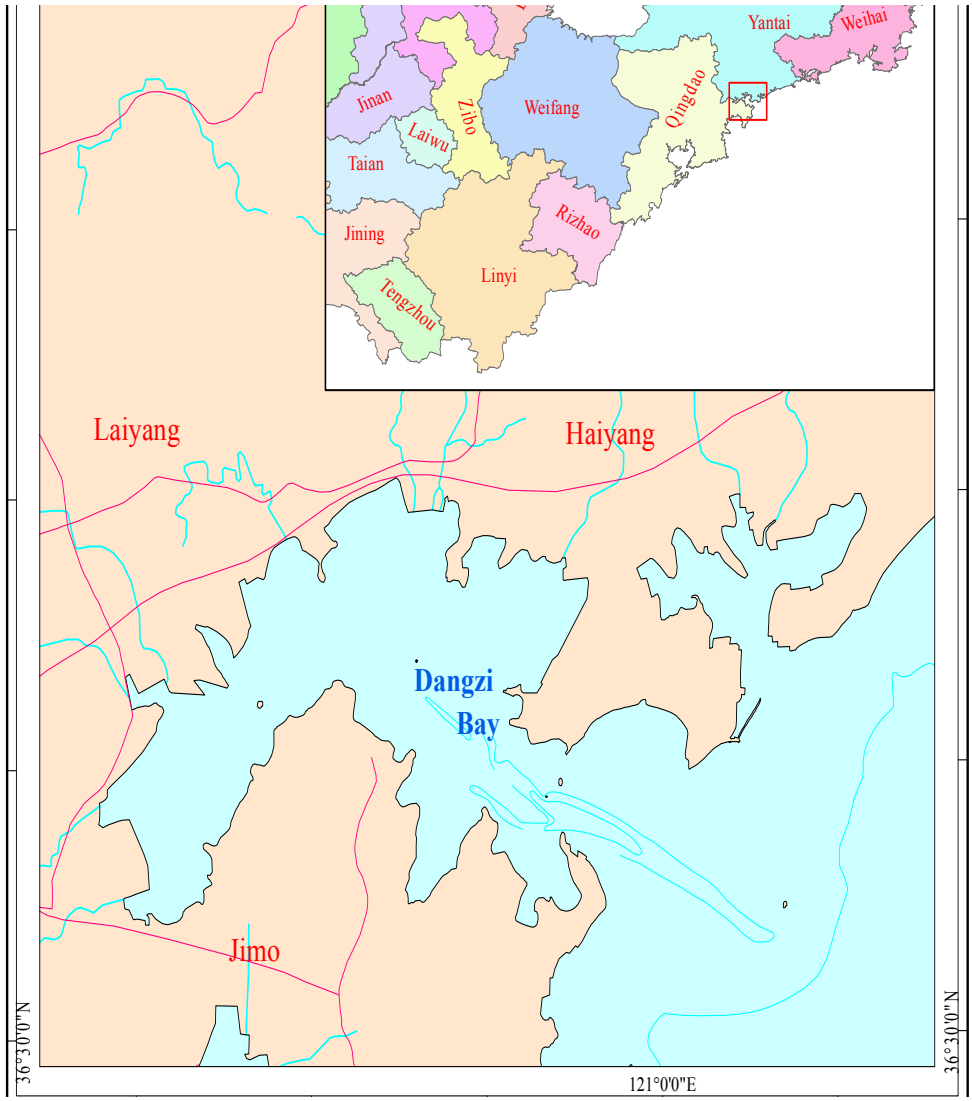

Fig 1-1. Location map of Dingzi Bay

Tab 2-1. Current area of sea use in Dingzi Bay

Region(km^2)		Jimo		Laiyang		Haiyang		total
		area	proportion	area	proportion	area	proportion	
Bay	Total area	71.3	40.4	36.3	20.5	69.0	39.1	176.6
	Sea area	70.8		36.3		67.6		174.7
	Islands area	0.5		0.02		1.4		1.9
area of reclamation for salt and Aquaculture		42.1		25.2		34.8		102.1
Outside dam	Total area	28.7	39.4	11.1	14.8	32.8	45.8	72.6
	Area of below 0m isobath	13.0	53.1	1.3	5.3	10.2	41.6	24.5

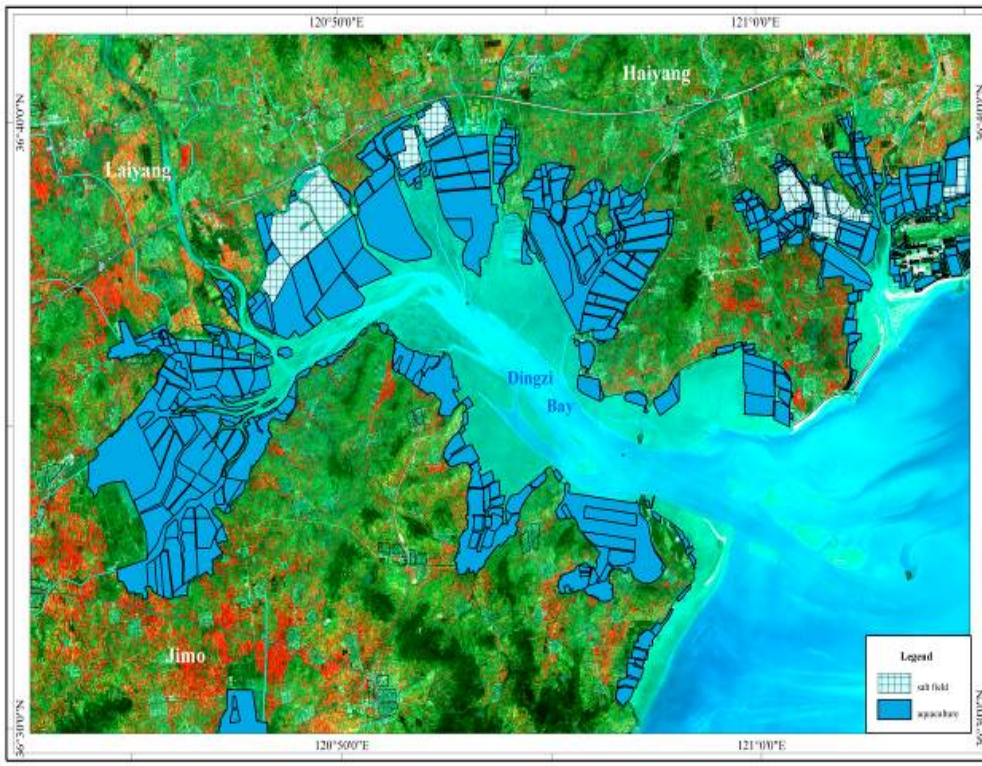

Fig 2-1. Current development and utilization of sea use situation in Dingzi Bay

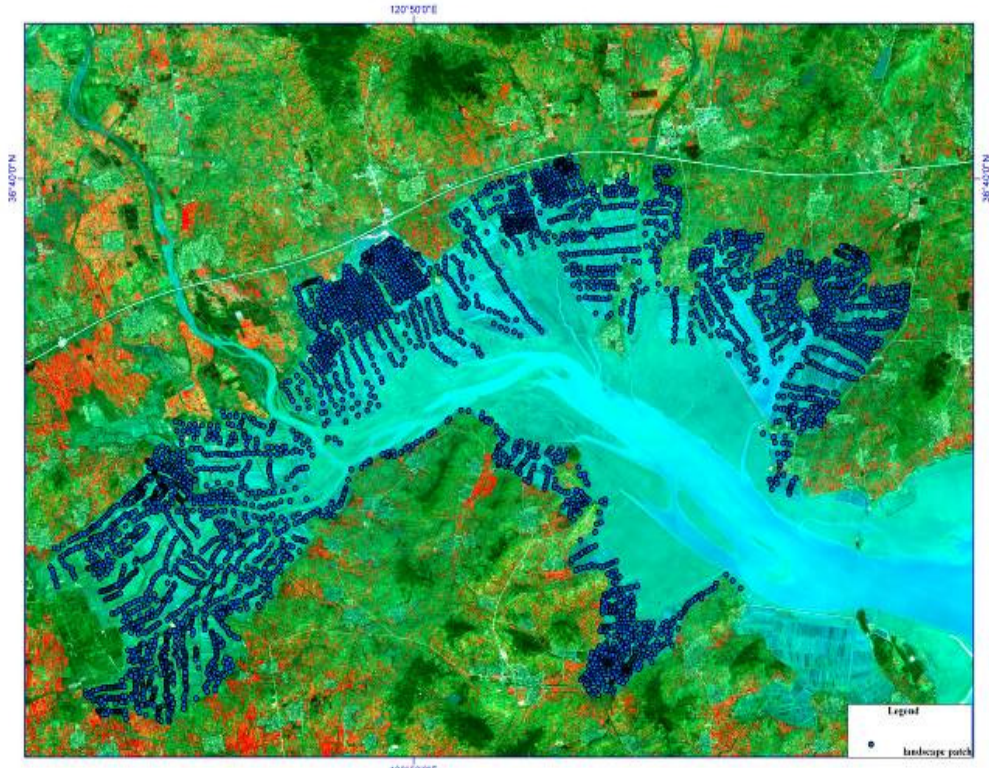

Fig 3-1. Distribution of landscape patch in Dingzi Bay

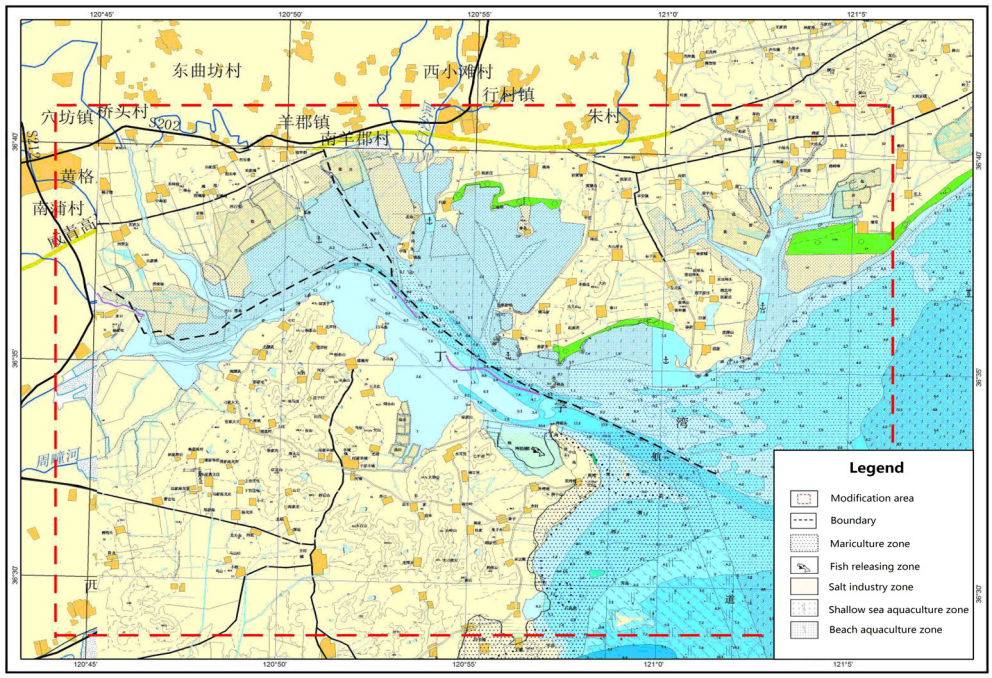

Fig 4-1. Marine functional zoning of Dingzi Bay (<Marine functional zoning of Shandong Province>(2004))

Fig 6-1. Distribution of tourism resources around Dingzi Bay

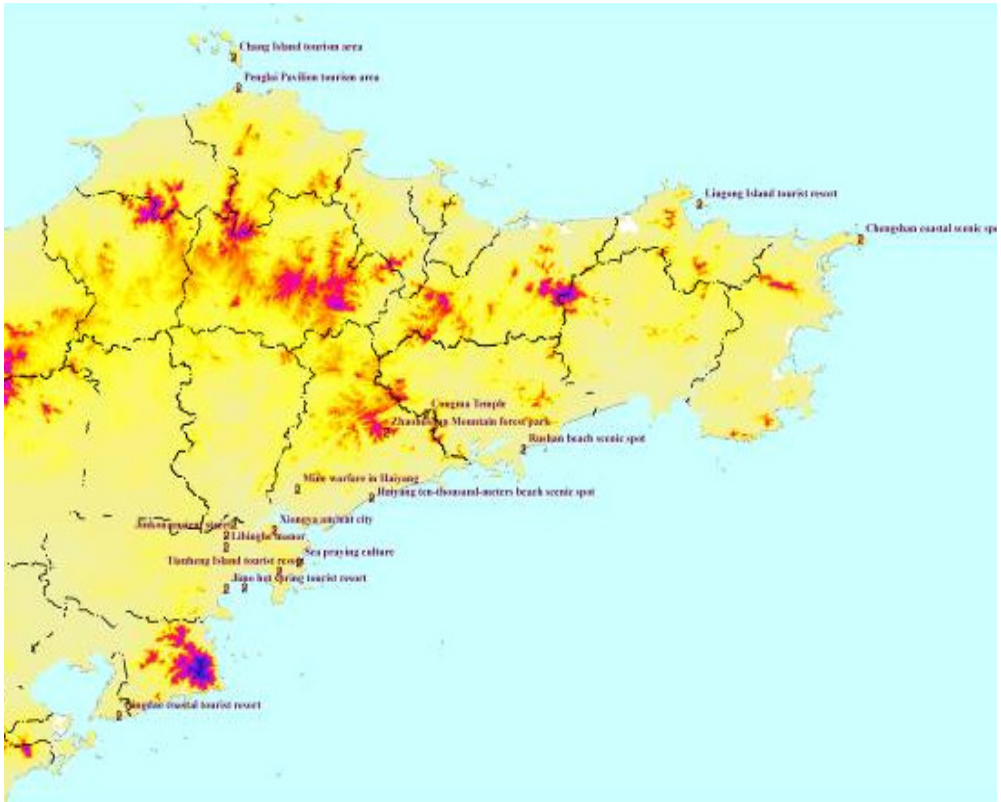

Fig 6-2. Distribution of tourism resources along Qingdao, Yantai and Weihai coast