

# Analysis on the Exploitability and Utilization of Sea Area Based on ESV: A Case Study of Dengsha Estuary Eco-region

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**Abstract**—The Dengsha estuary area is taken as the research area, and the value of marine ecological services is calculated from the perspective of opportunity cost, the exploitability of marine units is analyzed, and the current situation of marine utilization is analyzed and evaluated. By constructing an evaluation model of exploitability and utilization of sea area units, combining with GIS and model formulas, the value of marine ecological services and the exploitability and utilization of each type of sea area in sea area units are calculated. The results showed that: The effective exploitation and utilization of fishery seas in Dengsha estuary ecological zone is basically realized, and the ineffective utilization of industrial and mining seas is the main cause of ecological loss. The layout of Dengsha estuary should be further optimized, and the layout far away from the ecological core area should be adopted to improve the comprehensive benefits of using the sea.

**Keywords**—evaluation model of ecological benefit of sea area utilization; marine spatial planning; ecosystem service value

## I. INTRODUCTION

In the process of sustained and rapid development of coastal economy driven by marine economy, the demand for exploitation and utilization of marine resources is increasing. The scale of sea for transportation, industry and mining, fishery, reclamation and recreation has continued to grow.

The damage to the marine ecological environment in the process of development and utilization of the sea area cannot be ignored. The value of marine ecosystem services has attracted wide attention of domestic scholars, and has become a hot research topic in recent years. The results show that the loss of ecosystem service value is serious in the process of marine development and utilization, mainly due to the impact of urban expansion and reclamation activities [1-3].

Existing studies have focused on the calculation of ESV currency value, and analyzed the changes of ESV from a regional perspective[4-8]. There is no evaluation method for ESV of sea units. If ESV is assumed to be homogeneously distributed in sea area units, it will not be able to support the decision-making of sea area utilization layout.

How to consider the opportunity cost of sea area utilization in decision-making process, reduce ecological losses and enhance the comprehensive benefits of sea area utilization is of great significance to achieve sustainable development of

marine economy. In this paper, the Dengsha estuary area is taken as the research area, and the value of marine ecological services is calculated from the perspective of opportunity cost, the availability of marine units is analyzed, and the status quo of marine utilization is analyzed and evaluated.

## II. RESEARCH METHOD

### A. Evaluation Model for Exploitability and Utilization of Marine Units

Opportunity cost need to be considered in decision making on sea area utilization. Opportunity Cost of sea area utilization is the ecological value of the Sea area in the Non-exploitation and Utilization. When the comprehensive benefit (including economic benefit and ecological value) of the development and utilization of sea area units is greater than that of the non-development and utilization of sea area units, they can be exploited and utilized, otherwise their original ecological values should be protected. When there are many available types of units in the same sea area, choose the most comprehensive utilization type.

$$U_{(i,t)} = \begin{cases} 1, & F_{(i,t)} > V_{(i,t)} \\ 0, & F_{(i,t)} \leq V_{(i,t)} \end{cases} \quad (1)$$

$$F_{(i,t)} = M_{(i,t)} + E_{(i,t)}. \quad (2)$$

$$E_{(i,t)} = (1 - l_t) \cdot V_{(i,t)}. \quad (3)$$

In formula,  $U_{(i,t)}$  indicates the development and utilization of sea area units under the scenario of sea area utilization type  $t$ , 1 indicates development and utilization, and 0 indicates development and utilization;  $F_{(i,t)}$  represents the comprehensive benefits of sea area utilization,  $M_{(i,t)}$  represents the economic benefits of sea area units,  $E_{(i,t)}$  indicates the ecological value of sea area units after development and utilization,  $l_t$  is the ecological loss coefficient of  $t$  for sea area utilization, It is assumed that the ecological losses caused by different sea area units are identical.  $V_{(i,t)}$  represents the ecological value of sea units when they are not exploited and utilized.

The ecological value of sea area unit can be calculated according to the location weight of sea area unit and the

ecological service value of the whole ecological area under the  $t$  scenario of sea area utilization.

$$V_{(i,t)} = w_i \cdot ESV_t. \quad (4)$$

In formula,  $V_{(i,t)}$  indicates the ecological value of sea area unit under the condition of sea area utilization.  $w_i$  represents the weight of marine unit ecological value.  $ESV_t$  indicates the value of ecosystem services within the scope of study under the scenario of sea area utilization types.

When the economic benefit of sea area utilization is improved, the value of sea area ecological service is also increased at the same time. Assuming that the proportion of the economic benefits of each utilization type in the value of marine ecological services is certain, there is only one utilization type for a unit of sea area, and the economic benefits produced by each unit of sea area are the same. The value of marine ecological services can be calculated according to the economic benefits of various types of sea areas:

$$ESV_t = M_t \cdot R. \quad (5)$$

In the formula, the economic benefit of all sea area units in the study area is expressed under the  $t$  scenario.  $ESV_t$  indicates the value of marine ecosystem services when the utilization type of all sea area units is  $t$  and not exploited.  $R$  indicates that the economic benefit of sea area utilization accounts for the proportion of the value of sea area ecological service.  $M_t$  represents the economic benefits of the utilization

type of  $t$ .

#### B. Survey of the Research Area

Dengsha River is located in the east of Jinzhou District, Dalian City, Liaoning Province. It is  $39^{\circ}09'N \sim 39^{\circ}29'N$ ,  $121^{\circ}54'E \sim 122^{\circ}06'E$ . The whole river is 25.7 km long and the basin area is 229 km<sup>2</sup>. The coastline of both sides of the estuary is tortuous, and the shape of the estuary is about 3.5 km<sup>2</sup> bay. The water quality in the sea area is excellent, and the water depth is 0-5 M.

### III. RESULT ANALYSIS

#### A. Analysis of Exploitability and Utilization of Sea Area Units

1) *Spatial distribution characteristics of exploitability and utilizability of different utilization types.* Set  $R$  to 0.8. Selection of Major Sea Area Utilization Types in Liaoning Province: Sea for Transportation(T1), Industrial and mining sea(T2), Fishery sea(T3), sea reclamation(T4), And the Sea for Tourism, Leisure and Entertainment(T5), Calculating the Exploitability and Utilization of Sea Area Units. Figure1 shows the spatial distribution differences of exploitable units in different utilization types. The distribution range of exploitable units for tourism, leisure and recreation is all over the research scope. The distribution of fishery sea is close to the ecological core of estuary. The distribution of transportation sea and industrial sea is the same as that of mining sea. Distribution of reclamation land-use sea in remote ecological core area.



FIGURE 1. DISCRIMINANT RESULTS OF EXPLOITABILITY OF EACH TYPE OF SEA AREA UNIT

The number of exploitable units increases with the closer the exploitable location is to the ecological core area. Increased location and number of exploitable units have increased the possibility of sea area utilization layout. It also enlarges the scale of sea area utilization. It is important to note that this is only an analysis of the exploitability of each unit; it is assumed that the scale of development and utilization is reasonable. If the rationality of the scale of development and utilization is neglected, it is obviously unreasonable to reclaim

all the reclaimable units according to the above conclusions. The number of exploitable units for tourism & recreation is the largest, totaling 2240, followed by 2021 for fishery, 1528 for industrial, mining and transportation, and 1034 for reclamation and land reclamation.

2) *Impact of economic benefit change of sea area utilization on exploitability and utilization of sea area units.* The exploitability of exploitable location or sea area unit is not

related to the economic benefit of sea area utilization (the change of economic benefit of sea area utilization has no effect on the exploitability of sea area unit). From the distribution of existing results, the economic benefits per unit area of fishery seas are lower than those of transportation seas and industrial and mining seas, but they are closer to ecological areas and have more available units.

The economic benefit per unit area of the sea area is further validated and analyzed by changing the utilization types of each sea area: the economic benefit per unit area of transportation sea area is increased by 50%, the economic benefit per unit area of industrial and mining sea area is increased by 100%, and the economic benefit per unit area of fishery sea area is reduced by 50%. The exploitable location and the exploitability of sea area units remain unchanged. Therefore, the economic benefits of sea area utilization cannot determine whether the sea area unit can be exploited or utilized.

3) *The influence of the change of ecological loss degree of sea area utilization on the exploitability and utilization of sea area units.* The exploitability of exploitable location or sea area unit is related to the degree of ecological loss of sea area utilization. The existing results show that the smaller the ecological loss coefficient of each sea area, the closer the exploitable location is to the ecological area, and the more available units are.

Change the ecological loss coefficients of different types of sea areas for further verification and analysis: keep the economic benefits of unit area unchanged, further improve the ecological loss coefficients of fishery seas, making them the same as transportation seas, and the analysis results of fishery seas are consistent with that of transportation seas. Reduce the ecological loss coefficient of the tourist sea, making it the same as the industrial and mining sea, and the analysis results of the tourist sea are consistent with the industrial and mining sea. Therefore, the degree of ecological loss caused by sea area utilization affects whether sea area units can be exploited and utilized.

4) *The impact of relative price change on the exploitability and utilization of sea area units.* The R value is 30%, 60% and 90% respectively. The results of exploitability analysis of each utilization type of sea area unit show that: The change of R value causes the consistent change of exploitability of each utilization type of sea area unit. The exploitability of the same type of sea area unit varies inversely with R value.

When the R value is reduced to 30%, all the scenarios can not be exploited and utilized, and the tourism sea with the lowest ecological loss coefficient should be far away from the ecological core area. The development and utilization of important ecological protection areas should be far away from the ecological core areas, regardless of economic benefits. It is necessary to delimit the ecological red line to prohibit the exploitation and utilization of the sea areas with high ecological loss. The specific location of the ecological red line can be referred to the evaluation results of R value.

## B. Analysis of Current Situation of Marine Utilization

1) *Quantitative analysis of current units in marine utilization.* A total of 2 240 sea area units have been studied, of which 968 have been developed and utilized, 1272 have not been developed and utilized, and the utilization rate is 43.2%. There are two types of utilization: industrial and mining seas and fishery seas. The number of industrial and mining marine development and utilization units is 268, accounting for 27.7% of the total development and utilization units. The number of fishery marine development and utilization units is 700, accounting for 72.3% of the total development and utilization units.

2) *Comprehensive benefit analysis of current situation of sea area utilization.* The ecological value of sea area utilization unit is 7.19 billion yuan, and the comprehensive benefit of development and utilization is 6.135 billion yuan. Among them, the ecological benefit is 2.531 billion yuan, the economic benefit is 3.603 billion yuan, and the ecological loss caused by development and utilization is 4.658 billion yuan. The ecological value of industrial and mining sea units is 7.089 billion yuan, and the comprehensive benefits of development and utilization are 5.986 billion yuan. Among them, the ecological benefits are 2.481 billion yuan, and the economic benefits are 3.055 billion yuan. The ecological losses caused by development and utilization are 4.608 billion yuan. The ecological value of fishery sea unit is 101 million yuan, and the comprehensive development and utilization is 148 million yuan. Among them, the ecological benefit is 0.5 billion yuan, the economic benefit is 0.98 billion yuan, and the ecological loss caused by development and utilization is 0.5 billion yuan. Industrial and mining seas achieved 97.5% of the comprehensive benefits, but also caused 98.9% of the ecological losses.

3) *Effectiveness analysis of current situation of marine utilization.* The validity of sea area utilization is defined as that the comprehensive benefit of the development and utilization of sea area units is greater than the ecological value of non-development and utilization, that is, the exploitability and utilization of sea area units are equal to 1. According to the analysis results of exploitability of each utilization type of sea area unit, it is judged whether the current utilization status of sea area is located in each utilization type of exploitable unit. Effective utilization refers to the development and utilization of exploitable units, while ineffective utilization refers to the development and utilization of undeveloped units. The overall effective utilization rate is only 30% within the scope of the study. The number of effective utilization units in industrial and mining sea units is 0, and the effective utilization ratio is 0. The effective utilization unit of fishery sea is 687, and the effective utilization rate is 98%. Effective exploitation and utilization of fishery seas are basically realized. Ineffective utilization of industrial and mining seas is the main cause of ecological loss. The number of exploitable units of industrial and mining seas is 1528, which is enough to meet the current demand of using seas. If we adopt the layout

far away from the ecological core area, we can further reduce the ecological losses and improve the comprehensive benefits of industrial and mining seas. There are 23 ineffective utilization units in fishery seas, which are located near the ecological core area and are not exploitable. We should further optimize the layout and enhance the effectiveness of the seas.

#### IV. CONCLUSION

The research on the exploitability and utilization of marine units shows that: 1. The spatial distribution of exploitable units in different types of sea area is different. The development and utilization units of sea for tourism, leisure and entertainment cover the whole research area. The distribution of fishery sea is close to the ecological core of estuary. Transportation sea and industrial and mining sea have the same distribution position. The location of reclamation sea is far away from the ecological core. Assuming that the scale of development and utilization is reasonable, the number of exploitable units increases with the decrease of the distance between exploitable location and ecological core area. 2. The change of economic benefit of sea area utilization has no effect on the exploitability of sea area units. The economic benefit of sea area utilization cannot decide whether sea area units can be exploited or utilized. 3. The ecological loss caused by the utilization of sea area affects whether the sea area unit can be exploited and utilized. The smaller the ecological loss of utilization types in each sea area, the closer the exploitable location is to the ecological area, and the more available units are. 4. The change of the proportion of the economic benefits of sea area utilization to the value of marine ecological services causes the consistent change of the exploitability and utilization of each type of sea area unit. The exploitability of the same type of sea area unit and the proportion of the economic benefit of sea area to the value of marine ecological services change inversely.

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