# Study on Optimization of Sea Area Utilization: A Case Study of Dengsha Estuary

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***Abstract*—The contradiction between the development and utilization of the sea area and the ecological protection, as well as the double contradiction formed by the conflicts between the various departments, has become a difficult problem in the planning and management of the sea area. In this paper, ESV is calculated from the perspective of opportunity cost of the sea area utilization, and then the objective function of comprehensive benefit of sea area utilization is constructed. The sea area utilization of Dengsha estuary area is optimized based on the genetic algorithm. The results show that: 1) It can produce multiple optimization results of different layouts. 2) Compared with the initial population scheme the comprehensive benefit of the optimized scheme needs to be improved, and the ecological loss can be reduced at the same time. 3) The optimization result of the program on the conflict with the sea by coordination, each of the programs for the use of the sea type of development has reached the growth in demand for the sea.**

***Keywords—optimization; marine spatial planning; sea area utilization; ecosystem service value***

## I. INTRODUCTION

In the process of the marine economy driving the sustained and rapid development of the coastal areas, the demand for the development and utilization of sea resources is increasing. The scale of all types of sea use continues to grow. The contradiction between sea development and utilization and ecological protection is increasing. The research results show that the loss of ecosystem services during the development and utilization of the sea area is serious, mainly due to the impact of urban expansion and reclamation activities[1-2]. Existing research has focused on evaluating ESV monetary value and ESV change analysis from a regional perspective. There is a lack of evaluation method for sea area unit ESV from the perspective of opportunity cost. Therefore, it is difficult to maximize the comprehensive utilization of sea area.

Optimizing the allocation of sea space resources is a necessary means for coordinating the use of sea conflicts and achieving the dual goals of development and utilization and ecological protection. The optimization of sea area utilization is a multi-objective space optimization problem, which solves the problem of quantity distribution and spatial layout of various types of sea use. The existing marine zoning and planning techniques are still based on the suitability evaluation. Based on GIS, the superposition analysis method is used to solve the spatial layout problem of the departmental sea [3-5]. The superposition analysis method is cumbersome in solving multi-objective problems, has a large workload, low efficiency, and is greatly affected by human operation factors, making it difficult to implement the optimization process. The spatial resource allocation method based on intelligent optimization algorithm is rarely reported in the field of marine zoning and planning research.

In order to solve the above problems, this paper calculates the ESV from the perspective of opportunity cost in the sea area. On this basis, the comprehensive benefit objective function of sea area utilization is constructed. The genetic algorithm is used to optimize the sea area utilization, and the Dengsha estuary sea area is used as the research scope for empirical analysis.

## II. RESEARCH METHOD

### A. Objective Function

The sea area uses the optimal configuration adaptability to seek higher comprehensive utilization of sea area (Equation 1), and the comprehensive benefits include economic benefits and ecological values. No exploitation of ecological value is the development and utilization of the waters of opportunity cost. The comprehensive benefit of sea area utilization is the economic benefit and ecological value after development and utilization minus the ecological value of non-development and utilization.

$$F_{(i,t)} = M_{(i,t)} + E_{(i,t)} - V_{(i,t)} \tag{1}$$

In the formula, $F_{(i,t)}$ indicates the comprehensive benefit of sea area unit $i$ in the sea area utilization type $t$ scenario, $M_{(i,t)}$ indicates the economic benefit of the sea area unit, $E_{(i,t)}$ indicates the ecological value after the sea area unit development and utilization, and $V_{(i,t)}$ indicates the ecological value when the sea area unit is not developed and utilized.

## III. GENETIC OPERATOR

### A. Selection Operator

The operator is chosen to guide the evolution process to achieve the survival of the fittest in the population. The selection operator adopts the roulette selection method and selects according to the proportion of individual fitness in the population. The higher the individual fitness, the greater the probability of being selected, and the greater the probability that the individual genes are inherited to the next generation.

## IV. Crossover Operator

The general genetic algorithm uses random single-point or multi-point crossover to inherit the parental gene to the offspring. However, this method is not suitable for the optimal allocation of sea area utilization, which will lead to the random dispersion of the sea area of the progeny program. Even with the contiguous constraint, the efficiency is very low, it is difficult to produce the desired result. The crossover operator directly inherits the optimal allele of the parent to the offspring, that is, assigns the more beneficial type of the parental scheme to each seawater unit. The cross process itself reduces the randomness, and the result is derived from the optimal combination of parents, which is practical and efficient. The result of the crossover may lead to the growth of the utilization scale of the sub-generational scheme, and it is necessary to eliminate some super-scale utilization units according to the scale constraints. Based on the comprehensive benefit, the type of utilization unit is sorted, and the last elimination is adopted, and some super-scale sea area unit utilization types are assigned null values.

## V. Mutation Operator

The sea area utilizes the constraints of optimal configuration to define the scale and layout of the optimization plan, which can avoid the "out of order" sea area utilization optimization result. Constraints include two categories: scale constraints and condition constraints.

The scale constraint includes the constraint of the overall development and utilization area of each sea area utilization type and the sea area constraint of each sea project. The overall utilization scale of each utilization type can be set according to specific planning scenarios. The maximum size of the sea area utilization type in each scheme in the initial population can be the total scale of the most various types of sea demand.

Conditional constraints include geographic environment element constraints, competitive constraints, and effective use constraints. The constraints of geographical environment factors limit the conditions of geographical environment factors such as water quality, water depth and offshore distance for each utilization type. The competitive constraint defines the new layout utilization type to occupy the existing utilization type of the sea area unit. The effective use of constraints to ensure the new layout of the sea area unit to generate a comprehensive benefit is greater than the value of ecosystem services when not exploited.

## VI. Overview of the Research Area

Dengsha River is located in the eastern part of Jinzhou District, Dalian City, Liaoning Province, 39° 09′ N～39° 29′ N, 121° 54′ E～122° 06′ E. The whole river is 25.7km long and the drainage area is 229km2. The shoreline on both sides of the Dengsha River estuary twists and turns, and the area outside the estuary forms a bay of about 3.5km2. The water quality of the sea is excellent, and the water depth is 0-5m. The marine functional zoning is an industrial and urban construction area on both sides of the estuary, and some reserved areas outside the estuary. The northern part of the sand outside the Dengsha estuary is a port shipping area. The coastal zone around the Dengsha River estuary is within the radiation radius of Dalian's "1 hour economic circle", with convenient transportation and excellent logistics conditions. The Dengsha River Lingang Industrial Zone is an important support point for the "Five Points and One Line" Yellow Sea Economic Belt in Liaoning Province.

## VII. Result Analysis

### A. Initial Population Analysis

Based on the current situation of sea area utilization, the sea use demand under the scenario of an overall sea area development utilization rate increase of about 10% is simulated, and the initial population is constructed according to the sea demand. Simulate three types of development and utilization schemes for fishery sea, industrial and mining sea and tourism sea, and generate five plans for each sea area utilization type. The initial population evaluation results show:

The comprehensive benefit of industrial and mining sea growth plan increased by an average of 33.11%, and the ecological loss increased by 25.82% on average. The average level of new industrial and mining seas can improve the comprehensive utilization of sea areas. However, the ecological losses of different schemes can differ by 15%, and the ecological loss increases even more than the 10% new scale. Therefore, if the influence of the sea area utilization layout is neglected, the new development and utilization will only bring about greater ecological losses.

The comprehensive benefit of the fishery sea growth plan increased by an average of 4.88%, and the ecological loss decreased by an average of 0.24%. The increase in the comprehensive benefit level of new sea areas for fisheries use is lower than that for industrial and mining use, but the ecological loss may be reduced. The main reason for the decrease in ecological losses is that the newly added fishery occupies a small part of the sea for industrial and mining, and the ecological loss of the program is reduced due to the reduction in the scale of industrial and mining seas. The average comprehensive benefit level of the fishery sea growth plan is far lower than the industrial and mining sea plan. The higher comprehensive benefits of the industrial and mining sea plan bring higher ecological loss, and the marine ecological loss of the fishery is small, but the comprehensive benefit level is low, if in the two sectors,making choices in the program can be a dilemma.

The comprehensive benefit of the tourism sea growth program increased by an average of 1658.09%, and the ecological loss increased by an average of 199.74%. As a new type of sea area utilization, the new scale of tourism seas of the same scale will generate greater ecological losses, mainly because the economic benefits per unit area of tourism seas are higher, further enhancing the ecological value of the sea areas, even if the ecological loss during the development and utilization process . It is lower than the sea for industrial and mining use, but the value loss is even greater. The newly added tourism sea has achieved a substantial improvement in the comprehensive benefit level, and the average comprehensive benefit level is much higher than that of the industrial and mining sea and fishery sea use plan, and the overall benefit of sea area utilization is greater than the ecological loss. The tourism sea growth plan is not a perfect strategy. The growth demand of other departments is not only unsatisfied, but also partially occupied, which leads more sectoral need to be coordinated the maritime conflicts.

With the increase in the demand for sea use, the conflicts between difficult kinds of sea use demand have increased. There are 247 sea area units that use sea conflicts in the sea and marine use schemes for industrial and mining purposes. The sea use plan for tourism will lead to a further increase in the use of sea conflicts. After the new tourism sea program was added, there were 303 sea area units with sea conflicts. The number of contradictory sea area utilization units has accounted for 52% of the total development utilization units. From the perspective of their own use of the sea areas of each sector planning programmes will occupy each other the sea needs of other the sea needs of other sectors, and it also leads to the department sea area utilization plan unable to maximize the comprehensive benefit of regional sea area utilization. The number of sea units for fisheries in the industrial and mining sea program is reduced by an average of 45, the number of sea units for industrial and mining in the fishery sea program is reduced by an average of three, and the number of sea units for industrial and mining in the tourism sea plan is reduced by an average of 38. The average is reduced by 20. The use of maritime conflicts between types is yet to be coordinated.

## VIII. Optimization Result Analysis

In order to enable the crossover operator to calculate the ecological value of various types of sea area utilization types in the non-development and utilization scenarios, a non-development and utilization plan is added to the initial population. Set the optimal configuration model parameter crossover rate of 0.8, the mutation rate of 0.4, and the number of iterations of 100 times. The optimized configuration model was run 10 times to get 10 optimization schemes.

The optimization result scheme has improved comprehensive benefits compared with the initial population plan, and at the same time reduces ecological losses. The comprehensive benefit of the optimization result scheme is positive, and the scheme with the smallest comprehensive benefit is also 7.81% higher than the maximum comprehensive benefit plan of the initial population, the maximum increase is 40.84%, and the comprehensive benefit is increased by 30.28%. The ecological loss of the optimization result scheme is lower than the average of the tourism scheme in the initial population, and the average ecological loss of the optimization result scheme is reduced by 19.14% compared with the average value of the tourism scheme.

The optimization result scheme coordinated the conflicts in the use of seas. The scale of development and utilization of each type of sea use in each scheme has reached the growth demand of the various sectors. First, the crossover operator has retired the unreasonable development and utilization needs. When the non-development and utilization plan in the initial population crosses the development and utilization plan, if the comprehensive benefit of the development and utilization of the sea area unit is smaller than the ecological value of the non-development and utilization, the sea area unit will be assigned no value after the intersection. The optimization results show that the industrial and mining seas near the ecological core area has been cleaned out. Secondly, the mutation operator will randomly arrange the various types of sea demand under the guidance of constraints. The sea for industrial and mining is re-arranged in the sea area far away from the ecological core area. Due to the higher comprehensive benefits of industrial and mining seas, the original fishery sea position may be occupied, and the occupied sea use demand for fishery will be re-arranged under the action of the mutation operator.

The optimization results have the same sea area utilization structure, and the spatial layout difference produces different comprehensive benefits and ecological losses. Typical scenarios in the optimization results are scenario 2, scenario 6 and scenario 8. The tourism sea layout of Scheme 6 is closer to the ecological core area, and the ecological loss is the largest. However, under the premise of effective utilization, the ecological value of the sea area is fully utilized, and the ecological benefits after development and utilization are also the highest. Option 8 has the greatest comprehensive benefits and minimal ecological losses. The comprehensive benefits and ecological losses of Option 2 and Scheme 8 are basically the same, but the cost of Option 2 is not developed and utilized, that is, the comprehensive benefit of higher output per unit of ecological cost. Each optimization result scheme realizes the effective utilization of sea space resources, and which scheme can be selected by the sea area management organization.

## IX. Conclusion

In this paper, a method of sea area utilization optimized based on genetic algorithm is proposed, and basic principle and solution process of sea area utilization optimization based on genetic algorithm are expounded, configurations fitness evaluation model, genetic operator and constraint conditions are designed. Taking dengsha river mouth area as an example, the paper makes an empirical study. The results show that the optimization of sea area utilization based on genetic algorithm configurations method can produce a better comprehensive method can produce a better comprehensive benefit and lower ecological loss through the initial scheme. It can solve the problem of multi-sector sea conflict in the initial scheme. Under the guidance of constraint conditions, with higher comprehensive benefits as a competitive criterion, fully meet the needs of various departments with the sea. Under the same sea area utilization result, can produce the different space layout optimization plan, provides the more choice for the sea area management demand.

## ACKNOWLEDGEMENT

This research is financially supported by the National Natural Science Foundation of China (NO. 41601591).

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