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A GIS Platform Decoupled Evaluation Model of Sea Area Utilization Ecological Benefit

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***Abstract*—Evaluation of ecological benefit of sea area utilization is an important technology for decision support in marine spatial planning process. In this paper, a model of ecological benefit evaluation of marine based on lattice marine units is developed, in which the spatial data processing flow and non-spatial data processing flow are separated. The model calculation is decoupled with GIS platform, which is developed by object oriented programming. Two applications are developed based on the model, one is a comprehensive benefit analysis of maximum sea area utilization, and the other is an ecological benefit loss analysis of current utilization of marine. The model application results show that the model automated computing process based on different scenario parameters can support the decision making process of marine planning and management without GIS platform support.**

Keywords—evaluation model of ecological benefit of sea area utilization; geographic information system; decision support system

I. INTRODUCTION

Evaluation of marine ecological benefit is an important technical process in marine spatial planning [1-3]. The realization of the evaluation process of ecological benefit in exiting marine needs the support of GIS platform and the realization of professional operation. It takes a long time for the data analysis operation to get the planning cycle. This is often said that the planning cannot catch up with changes. The existing ecological benefit method is difficult to meet the application needs of decision support in planning and management [4-8]. The evaluation of ecological benefit of existing marine is based on the whole research area, and the ecological benefit of different locations in the whole research area is homogeneous. It is difficult to distinguish the difference of ecological loss in the utilization of the marine by development in different locations without the evaluation of the ecological benefit of the use of different seas. This will lead to higher ecological costs in the use of space layout in the marine.

In this paper, a model of ecological benefit evaluation of marine based on lattice marine units is presents, in which the spatial data processing flow and non-spatial data processing flow are separated. The model calculation and GIS platform are decoupled, and the whole model calculation flow is realizes by object oriented programming. Development introduced the application of the comprehensive benefit analysis of maximum utilization of marine and the ecological benefit loss analysis of current utilization of marine. The model application results show that the model automated computing process can obtain the results of ocean planning and management decision support based on different scenario parameters without GIS platform support.

II. EVALUATION MODEL OF ECOLOGICAL BENEFIT OF SEA AREA UTILIZATION

The marine has the ecosystem function service value. The research shows that the economic and social benefits of the utilization of the marine are part of the value of ecosystem services. It defines the use of ecological benefits to remove the economic and social benefits from the service value of marine ecosystem. The definition of ecological benefit of marine ecosystem under the condition of basic health function, and is also the cost of ecological environment used by development. Based on the structural relationship between ecological benefits and economic and social benefits of the functional service value of the marine ecosystem, the ecological base value of the marine can be estimated based on the economic and social benefits of the marine. The ecological base value of sea area is a reference value of ecological environment cost of marine development, which increase with the economic and social benefits of marine.

The ecological benefit of the marine is affected by the health degree of the marine ecosystem. The water quality of the sea area can affect the value of ecosystem services such as biodiversity, and can be used as an index to evaluate to estimate the level of ecological benefits. The deterioration of the water quality of the marine will lead to the reduction of the utilization of ecological level. The improvement of the water quality of the marine can bring about the improvement of the utilization of ecological benefits.

The utilization of development will have different effects on the ecological environment of the sea areas. The effects of different sea area utilization types on ecological benefit of marine are different. Based on the research results of marine public welfare projects, the ecological environmental damage degree coefficient of different sea area utilization types was uses to estimate the ecological benefit of different sea areas.

Considering the factors affecting the ecological benefit of the above sea area, the calculation model of the utilization of ecological benefit in the sea area can be expresses as:

$$EEB = E_i \cdot D_t \cdot H \quad (1)$$

EEB in the formula is the ecological benefit of sea area utilization, E_i is a marine unit ecological base value, D_t is the coefficient of ecological environmental damage of sea area utilization type t, H is the sea water quality condition coefficient.

There is a difference in spatial distribution of ecological base values. The ecological base value of different sea areas is lower with the distance from the ecological area. The spatial difference distribution characteristics of ecological base values can be expresses by the distance attenuation model.

$$C_d = \left(1 + d_i / d_{\max}\right)^{-k} \quad (2)$$

C_d in the formula is the degree of influence of the distance of ecological base value, d_i indicates the distance of the marine unit from the ecological zone. d_{max} Indicates the maximum distance of a marine unit from an ecological zone, K indicates the distance attenuation coefficient.

The spatial distribution model of ecological base value in the sea area is based on the distance influence degree to express the spatial distribution difference of ecological base value.

$$E_i = E \cdot C_{di} / \sum_{i=1}^{n} C_{di} \quad (3)$$

E_i in the formula is the unit ecological base value, E is the ecological basis values for the entire range of studies. C_{di} is the influence degree of ecological base value distance of marine unit.

III. Process of Ecological Benefit Evaluation Model

The technological process of the calculating ecological benefits in the sea are mainly includes four steps: determining the scope of research, creating spatial units, calculating ecological base values and calculating ecological benefits. The implementation process includes the space data calculation process and the non-spatial data calculation process.

Determine the study area. The study area is a certain area of sea area, according to the ecosystem-bases management vision, can build the research area based on the sea area. The research area bases on the sea area. The research scope should include the ecological area of the sea are and the sea area within a certain distance. Research scope stores as vector polygon spatial data file.

Create spatial units. The sea area spatial unit use point data to express specific position information, and creates the sea area spatial unit based on the study area. The specific creation process first marrows study area to a certain resolution, the raises the grid central coordinate information to create the vector point data file.

Calculate the ecological base value. Bases on the ecological base value of the research area, the ecological base value of the marine unit is calculated according to the distance influence degree of the area. The research scope of ecological base value refers to the relevant research of ecological service value and the economic benefit of each sea area is estimated in combination with the utilization type. The distance influence degree of the ecological zone in the sea area, the calculation of the distance between the units of the sea area and the ecological zone of the sea area according to the formula.

Calculate ecological benefits. Based on the base value of the marine unit, the ecological benefit of the marine unit, the ecological benefit of the marine unit is calculates according to the water quality condition coefficient of the marine unit and the degree of damage of the ecological environment of the specific sea area. The water quality condition of the sea area unit is the result of the superposition analysis of the spatial distribution map of the sea area unit and sea area water quality condition. The degree of damage of marine type ecological environment is derived from tabular data.

IV. Model Application

A. Maximum Benefit Analysis of Sea Area Utilization

The purpose of maximum comprehensive benefit analysis of sea area utilization is to determine whether the sum of benefits (comprehensive benefits) and economic benefits of each unit for development and utilization of a certain type of utilization can be greater than the unexploited use ecological benefits. Set up separately full development and utilization scenarios and completely unused scenarios for each utilization type, that is, all sea area units are not exploited or fully exploited by one type of utilization, and then calculated the maximize results of comprehensive benefits of full development and utilization and unutilized utilization.. The results of maximizing the comprehensive benefits of each sea area utilization type show that each unit is not exploited or exploited, and the total results of all exploitable units indicate the development and utilization capacity of the area for this type of sea area utilization.

The spatial distribution map of the comprehensive benefit maximization of each sea area utilization type (Figure 1) shows the comprehensive benefit maximization spatial distribution difference of each sea area utilization type. The fishery sea can be developed and utilized in comparison with industrial and mining seas, and it is also possible to develop sea area units closer to the estuary ecological zone. The tourism sea can be fully exploited and utilized throughout the region. The reclamation land should be kept away from the estuary and the bay ecoregion, in the sea area with lower ecological benefits.

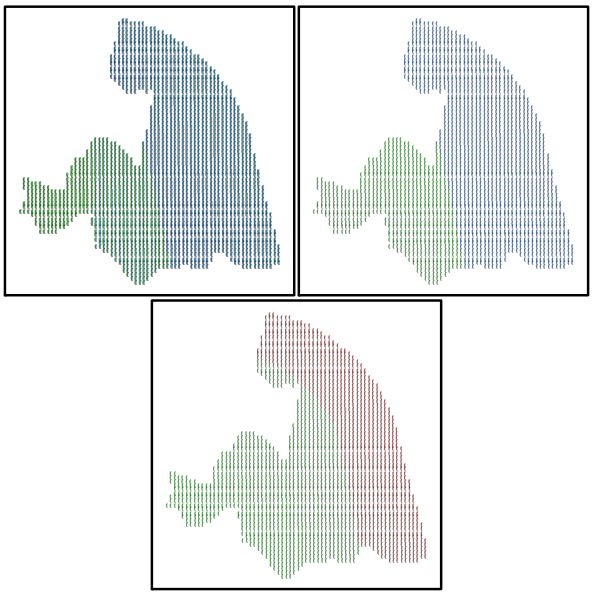

FIGURE I. SPATIAL DISTRIBUTION MAP OF THE COMPREHENSIVE BENEFIT OF EACH SEA AREA UTILIZATION TYPE

The distance between the development and utilization units of each utilization type from the ecological zone shows that the sea for transportation and the sea for industrial and mining economic benefits per unit area are different, but the distance values are the same. Observing the model parameters, it is found that the sea for transportation has the same ecological loss coefficient as the sea for industrial and mining. It is further assumed that the distance value is related to the loss coefficient of each sea area utilization type, and is not related to the economic benefit per unit area. The ecological loss coefficient of each sea area utilization type is modified to 0.65, and the economic benefit per unit area remains unchanged. The result is the same distance value, which proves that the development and utilization units of each utilization type which are closet ecological area relate to the ecological loss coefficient, and is not related to the economic benefit per unit area. The coefficient is related and is not related to the economic benefit per unit area. The closer the exploitable units of each utilization type are to the ecological zone, the greater the bearing capacity of the zone for this type of sea use. Therefore, the lower the degree of ecological loss of the sea area utilization type, the greater the carrying capacity of the area for this type of sea area utilization.

B. Ecological Benefit Loss Analysis of Sea Area Utilization

Comparing the consistency of the sea area utilization of each sea area with the maximum benefit analysis result of the sea area utilization, if the comprehensive benefit maximization result value of the unit development and utilization type is unexploited, the sea area utilization status has an ecological benefit loss, and the loss size is equal to the unit comprehensive benefit maximization result maximizes reduces the economic benefits of development and utilization. Compare the overall scale of a certain type of sea area utilization with the development and utilization capacity of the sea area utilization maximum comprehensive benefit, if the sea area development and utilization capacity is greater than the overall scale of the sea area utilization status, it indicates that the area can support the type of sea area development. And if the type of sea area development and utilization is less than the overall size of the sea area utilization status, it indicates that the area cannot support the development and utilization of this type of sea area.

The current status of sea area utilization shows that there are two types of sea areas for industrial and mining use and fishery use in the region. The number of sea units for industrial and mining use is 268, and the sea carrying capacity for industrial and mining use is 1521. The current development and utilization demand only accounts for 17.6%, and the number of units which are inconsistent with the maximum comprehensive benefit results was 268, resulting in the ecological benefits loss about 166.364 million yuan. The number of sea units for fishery is 700, and the sea-capacity for fishery is 2028. The existing development and utilization demand accounts for 34.5% of the bearing capacity. The number of units that are inconsistent with the comprehensive benefit maximization result is 13, resulting in an ecological benefit loss of about 3.75 million yuan.

V. SUMMARY

This paper proposed a sea area utilization ecological benefit evaluation model based on the lattice sea area unit. The model has the following advantages: 1) it can calculate the ecological benefits of sea areas at different locations within the research scope. Therefore, it can distinguish the ecological loss about the use of various types of sea areas in different locations.2) The spatial data processing flow is separated from the non-spatial data processing flow in the model calculation process, and the model calculation is decoupled from the GIS platform.3) Based on the model, the ecological benefit loss analysis application of sea area utilization maximization comprehensive benefit analysis and sea area utilization status is developed, which can obtain the results of marine planning and management decision support according to different scenario parameters without the support of GIS platform. .

The model can be further extended according to the data of the research scope. The main extended application directions include: 1) The ecological base value can be estimated based on the spatial heterogeneous distribution simulation results of the economic benefits.2) Combine with the evaluation of the value of ecosystem services, and use the value of regional ecosystem services as the ecological basis.3) Further study the differences in ecological losses caused by sea area utilization, and combine different technical scenarios to achieve dynamic evaluation of sea area utilization ecological benefits and serve the sea area adaptive management framework.

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