Analysis of Energy Flow in the Sea Area of Zhongjieshan Islands and Assessment of Ecological Capacity of Sepiella Maindroni Based on Ecopath Model

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Abstract. Sepiella maindroni was once one of the four traditional marine products in our country. In order to evaluate the ecological capacity of Sepiella maindroni in the sea area of Zhongjieshan Islands, this study used Ecopath with Ecosim 6.5 (EwE) software to construct an Ecopath model composed of 17 functional groups in the sea area of Zhongjieshan Islands. The nutrient structure and energy flow characteristics of the sea area of Zhongjieshan Islands are analyzed from the ecosystem level, and the reasonable ecological capacity of the sea area of Zhongjieshan Islands is estimated by the model.The results show that the trophic level of each functional group in the marine ecosystem of the Zhongjieshan Islands is between 1-4.648, total primary production/total respiration is 4.539, the system Connectance Index is 0.478, the System Omnivory Index is 0.389, The trophic level of Sepiella maindroni is 3.562, and the Ecotrophic Efficiency is 0.306, indicating that the Ecotrophic Efficiency of each trophic level in the system is low and the energy is not fully utilized. There is still room for breeding and exile for the Sepiella maindroni. The model estimates that the ecological capacity of Sepiella maindroni is about $2t\cdot km^2$.

1 Introduction

Sepiella maindroni, commonly known as cuttlefish, belongs to the class Cephalopods. It is widely distributed along the coast of our country and is one of the four major fishery products in the East China Sea. But due to human large-scale fishing and unreasonable use, the resources of Sepiella maindroni decreased sharply in the early 1980s and almost disappeared in the 1990s. The resource situation is worrying. In recent years, in order to restore the resource amount, Zhejiang Fisheries has actively carried out resource enhancement measures combining artificial breeding of seedlings and release, and carried out large-scale reproduction and release work, but it still cannot meet the requirements of the recovery of the Sepiella maindroni resources. The current research on the resource recovery of Sepiella maindroni mainly focuses on the biological characteristics and seed breeding [1-6]. There are relatively few studies on the evaluation of its ecological capacity. In previous studies on the Sepiella maindroni, many experts and scholars have carried out some studies on its biology, reproductive habits, migration distribution, resource status, etc. Tang Yimin and others investigated the species of phytoplankton in the spawning ground area of Zhongjieshan. Zooplankton species, benthic species composition and main species distribution and changes.

At present, most of the assessment for ecological capacity is done by models. Some models require too many parameters and the operation of the model is more complicated. Therefore, relatively speaking, the Ecopath model constructed by EwE software is an ideal tool for studying biological ecological capacity because of its convenient operation and its ability to cover all limiting factors of ecological capacity. Ecological carrying capacity assessment is the basis and prerequisite for carrying out the conservation of biological resources and maintaining the health of the ecosystem.

The sea area of Zhongjieshan Islands is located in the east of Zhoushan Islands New Area. The superior geographical location and marine environmental conditions make it an important habitat for the reproduction, feeding and growth of many marine organisms. The biodiversity of this sea area is relatively high, which has high research value, economic value and protection value. The Sepiella maindroni is also one of the most representative biological species in the sea area, and it is also an important resource protection and restoration species. In this study, by constructing the Ecopath model in the sea area of Zhongjieshan Islands, the nutrient structure and energy flow characteristics in the sea area of Zhongjieshan Islands were analyzed from the ecosystem level. The model is used to estimate the release flow, determine the reasonable flow and scale of the biological resources, and evaluate the ecological capacity of the growth of Sepiella maindroni, in order to provide help for the subsequent construction of the Sepiella maindroni Habitat. In this study, when using the

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Ecopath model to estimate the ecological capacity of the proliferation species, the Ecotrophic Efficiency can be maximized from the perspective of the ecosystem food web and food chain, and the number of released species can be maximized without destroying the own ecosystem. , To utilize the energy of the ecosystem as much as possible, to ensure the survival rate of proliferation species, and to promote the development of "productive" fisheries.

2 Materials and Methods

2.1 Model principle

The Ecopath model is an important module in the Ecopath with Ecosim (EwE) software. It is an important method for studying the energy flow and material circulation of the ecosystem. Its main content is to quantitatively describe the flow of energy between the biological components of the ecosystem by determining the important ecological parameters of the ecosystem such as biomass, production, consumption, and ecological nutrient conversion efficiency according to the law of conservation of energy.

The definition of the Ecopath model requires that the ecosystem is composed of a series of interrelated functional groups, and that all functional groups must cover the entire process of the energy flow of the ecosystem. The system function group can include organic debris, plankton, and a function group consisting of fish species of the same size, age, or ecological characteristics. According to the principle of thermodynamics, the Ecopath model defines the energy output and input of each functional group in the system to maintain a balance, that is, production-predator death-other natural death-output = 0. The model defines the ecosystem with a set of simultaneous linear equations, where each linear equation represents a functional group in the system, expressed by the following mathematical formula:

$$P_i = Y_i + B_i + B_i + M_{2i} + E_i + B_{Ai} + M_{0i} + B_i$$

$$Q_i = P_i + R_i + U_i$$

Among them: $M_{0i} = \frac{P_i \times (1 - EE_i)}{B_i}$,

$$M_{2i} = \sum_{j=1}^{n} \frac{Q_j \times DC_{ji}}{B_i}$$

P_i is the production of organisms in functional group i, Y_i is the total catch, B_i is the biomass, E_i is the net migration, B_{Ai} is the biomass accumulation, R_i is the respiration, U_i is the amount of undigested food, and Q_i is Consumption, M_{0i} is other mortality, M_{2i} is predation mortality, EE_i is the Ecotrophic Efficiency of functional group i, which refers to the proportion of production used in the system,. See Table 1 for specific definitions. In the Ecopath model, at least 3 of the 4 parameters of B_i, $(P/B)_i$, $(Q/B)_j$ and EE_i must be known, and one unknown parameter can be calculated by the model inferred.

Table 1. The interpretation of each parameter in the Ecopath model

parameter	definitions
P_i	production of organisms in functional group i
Y_i	Catch of organisms in functional group i
B_i	Biomass of organisms of functional group i
E_i	Net migration of organisms of functional group i
B_{Ai}	Biomass accumulation
M_{0i}	Other biological mortality of functional group i
M_{2i}	Mortality of predator in functional group i
EE_i	Ecotrophic Efficiency of functional group i
DC_{ji}	The biological composition ratio of predator functional group i to predator functional group j

2.2 Functional group division

Based on the existing biological community structure and model calculation rules in the sea area of Zhongjieshan Islands, this study will analyze the species with a high degree of overlap in the niche (food composition, age composition, feeding method, individual size, and statistical classification method of catches). Merged to simplify the food web and divide organisms with similar functional status into a functional group. According to the existing survey data, in this study, the marine ecosystem in the sea area of Zhongjieshan Islands is divided into 17 functional groups.

The functional groups basically cover the entire process of energy flow of the marine ecosystem in the sea area of Zhongjieshan Islands, including Detritus, phytoplankton, zooplankton, meiobenthos, Benthic crustaceans, shrimps, crabs, cephalopods, Sepiella maindroni, Larimichthys polyactis, Anchovy, Small benthic fishes, other pelagic fishes, Large yellow croaker, Large demersal fishs, Trichiurus lepturus, Other piscivorous fishes.

Since this article mainly focuses on the breeding and release of Sepiella maindroni, we set it as a functional group separately. See Table 2 for the division of specific ecosystem model functional groups.

Table 2. The functional groups and main biological species of the Ecopath model in the sea area of Zhongjieshan Islands

Serial number	Functional groups	Main species
1	Other piscivorous fishes	Lophius litulon Champsodon snyderi
2	Trichiurus lepturus	
3	Large demersal fishes	Muraenesox cinereus Paralichthysolivaceus
4	Large yellow croaker	
5	other pelagic fishes	Pampus argenteus Coilia mystus
6	Small benthic fishes	Priacanthus tayenus Acropoma japonicum
7	Anchovy	Setipinna taty anchovy
8	Larimichthys polyactis	
9	Sepiella maindroni	
10	cephalopods	Uroteuthischinensis Uroteuthisduvauceli Sepia aculeata
11	crabs	Charybdis japonica Portunus trituberculatus Charybdis bimaculata
12	shrimps	Palaemon gravieri Oratosquilla oratoria Alpheus distinguendus
13	Benthic crustaceans	shellfish snails
14	meiobenthos	Granulifusus kiranus Polychaeta
15	zooplankton	siphonohora Chinese stinging algae Sagitta
16	phytoplankton	Noctiluca scintillans coscinodiscus jonesianus prorocentrum donghaiense
17	Detritus	

2.3 Model data and parameter debugging

2.3.1 Model data

In the Ecopath model, the movement of energy in the system can be expressed in the form of energy (for example, biological wet weight t/km^2), and the length of time is generally one year. The biomass (B) data in the model is generally estimated from survey data, and the phytoplankton biomass can be calculated by converting the ratio of the chlorophyll a concentration to the carbon content of phytoplankton. The biomass of organic detritus can be estimated according to the empirical formula of organic detritus and primary production carbon [7]; Production/biomass (P/B) data is also called biomass turnover rate, which refers to the ratio of production to biomass per unit time. The unit is 1/y. Generally speaking, in a balanced and stable ecosystem, the P/B value of fish is equal to the total instantaneous death Z [8], Calculate according to the formula Z=M+F. M is the natural mortality rate, which can be calculated using the empirical formula of the growth function [9], F is the fishing mortality rate. Consumption/Biomass (Q/B) refers to the ratio of a certain animal's food intake to its biomass per unit time (usually one year). The unit is 1/y. The P/Q coefficient refers to the ratio of a certain animal's production to food intake, that is, the reciprocal of the food coefficient. When Q/B is difficult to calculate, if you know P/B and P/Q, you can also calculate Q/B. The Q/B value of fish can be calculated according to the multiple regression model of the fin profile ratio [10].

The fishery resource data of the ecosystem in the sea area of Zhongjieshan Islands are mainly derived from the collection and analysis of environmental field data and historical data, and are obtained through the analysis and collation of historical literature data on fishery resources and ecological environment. As part of the data of P/B and Q/B is difficult to obtain, this model refers to the model data with similar ecosystem characteristics in the sea area of Zhongjieshan Islands, such as the relevant system parameters of the Ecopath model in the East China Sea.

2.3.2 Parameter debugging

The debugging process of the Ecopath model is the process of keeping the ecosystem and the input and output of each functional group in balance [11]. The basic condition of ecosystem balance is that the EE of each functional group is between 0 and 1. When EE reaches 1, it means that the functional group is under predation pressure from other functional groups or fishing pressure is overly heavy [12]. In this study, when inputting the raw data in the sea area of Zhongjieshan

Islands, the EE value (Ecotrophic Efficiency) estimated by the input parameters is greater than 1, indicating that the model is unbalanced, and it is necessary to repeatedly adjust the unbalanced functional groups and the related food habits. P/B, Q/B values and food composition of functional groups. The debugging results make the EE of all functional groups in the model ≤ 1, and the input and output are kept in balance, so as to obtain reasonable values of other ecological parameters of the ecosystem [13].

3 Results and Discussion

3.1 Analysis of functional group trophic level and Ecotrophic Efficiency

In the Ecopath model of the sea area of Zhongjieshan Islands, the input and output parameters after debugging are shown in Table 3. The EE value of each functional group of the marine ecosystem is less than 1 (0.066-0.729). Among them, the EE value of the Sepiella maindroni is 0.306, which is at a medium level in the ecosystem. According to the diet analysis matrix, the trophic level of the functional group of the marine ecosystem is 1-4.648, and the entire ecosystem can be divided into 5 trophic levels. The P/Q values of all functional groups are 0.268-0.476, and the results are reasonable. In addition, some parameters missing from the model can be estimated by the model.

Table 3. Basic input parameters and estimated parameters of Ecopath model in the sea area of Zhongjieshan Islands

Serial number	group	trophic level	biomass (t·km^2)	Production /Biomass (P/B)	Consumption /Biomass Q/B	Ecotrophic Efficiency (EE)	Production /consumption (P/Q)
1	Other piscivorous fishes	4.648	0.19	1.1	4.1	0.382	0.268
2	Trichiurus lepturus	4.407	0.104	2.2	5.9	0.268	0.373
3	Large demersal fishs	4.317	0.524	1.525	4.7	0.154	0.324
4	Large yellow croaker	4.080	0.21	2.42	6.46	0.557	0.375
5	other pelagic fishes	3.843	0.25	2.61	8.7	0.590	0.300
6	Small benthic fishes	3.734	0.56	6.6	15.4	0.729	0.429
7	Anchovy	3.453	0.39	4.9	10.8	0.488	0.454
8	Larimichthys polyactis	3.284	0.45	7.05	14.8	0.452	0.476
9	Sepiella maindroni	3.562	1.3	4.59	15.55	0.306	0.295
10	cephalopods	3.085	2.8	6.9	17	0.335	0.406
11	crabs	3.025	3.21	9.1	21	0.396	0.433
12	shrimps	2.833	4.68	9.9	23	0.532	0.430
13	Benthic crustaceans	2.762	6.89	10.65	26.9	0.582	0.396
14	meiobenthos	2.442	12.96	12	35	0.651	0.343
15	zooplankton	2	25.85	45	150	0.263	0.3
16	phytoplankto n	1	150.8	70		0.351	
17	Detritus	1	500			0.066	

3.2 Trophic level and food web structure

3.2.1 trophic level analysis of functional groups

The trophic level distribution of the ecological function group in the sea area of Zhongjieshan Islands shows in Figure 1. The lowest trophic level is detritus and phytoplankton, the trophic level is 1, and the highest trophic level is other piscivorous fishes. The trophic level of the Sepiella maindroni is 3.562, which belongs to the middle trophic grade in the surveyed sea area. It can be seen from Figure 1 that there are 5 trophic levels in the ecosystems in the sea area of Zhongjieshan Islands. The first trophic level is organic detritus and phytoplankton; the second trophic level includes zooplankton, meiobenthos, etc.; the third nutrition level Levels include Larimichthys polyactis, Small benthic fishes, etc. the fourth trophic level is mostly omnivorous fish; the fifth trophic level is mostly Other piscivorous fishes.

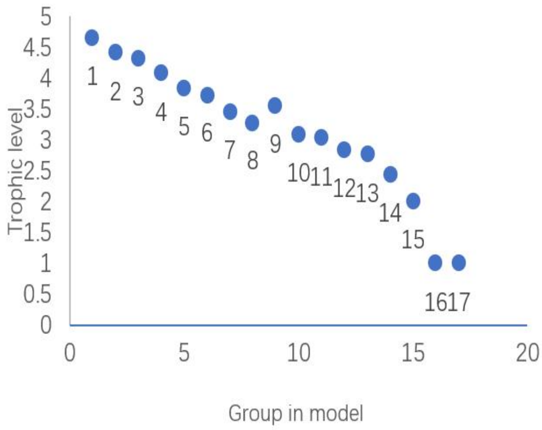

Fig.1 The trophic level of the ecological function group in the sea area of Zhongjieshan Islands,
Refer to Table 2 for the number of function groups

3.2.2 Food web structure analysis

Figure 2 is the food web structure of the ecosystem in the sea area of Zhongjieshan Islands. This figure shows the nutrient flow relationship of all functional groups in the entire study area and the influence of food competition and mutual predation between biological functional groups in the ecosystem. The circles and sizes in the figure represent the size of each functional group and biomass in the system. The lines represent the transfer of energy between the functional groups. The thickness and color of the lines represent the amount of the energy flow. It can be seen from Figure 2 that the Zhongjieshan Islands of the energy flow in the seas is mainly concentrated between trophic levels I to IV, along two paths, one is a detrital food chain starting from organic detritus, and the other is a pastoral food chain starting from phytoplankton. The energy of the system is provided by detritus and phytoplankton, and the energy gradually decreases from low trophic level to high trophic level.

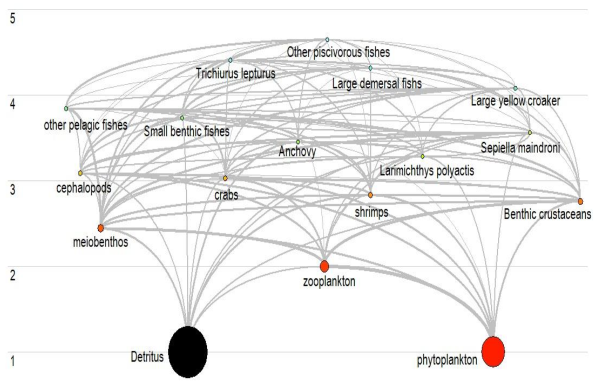

Fig.2 Schematic diagram of the energy channel of the ecosystem in the sea area of Zhongjieshan Islands

3.3 Nutrient structure and energy flow

In the Ecopath model, each functional group species is allocated to different integrated trophic levels according to the proportion of foods of different trophic levels in their food sources. The distribution of the energy flow of each functional group in the integrated trophic level is expressed in terms of relative flow and absolute flow. The integrated trophic level of the marine ecosystem of the Zhongjieshan Islands obtained by the model operation is composed of I-XII. Since the flow of the trophic level VII-XII is relatively small, it can be ignored in this study. Therefore, it can be considered that the marine ecosystem of the Zhongjieshan Islands consists of VI trophic level. Table 4 shows the energy flow of each integrated trophic level in the ecosystems to the sea area of Zhongjieshan Islands. The sea ecosystems of the Zhongjieshan Islands include VI trophic levels. We can see from Table 4 to Table 6 that the distribution of energy flow is mainly concentrated in the first IV trophic levels. The total energy flow of the system is 24154t/km^2/y. The total flow of the first trophic level is 19362t/km^2/y, accounting for 80.16% of the total energy flow of the ecosystem; the predation is 4286t/km^2/y, accounting for 89.55% of the total food intake. The total energy flow of the second trophic level is 4286 t/km^2/y, accounting for 17.74% of the total energy flow of the system, of which the energy flows for predation, inflowing debris and breathing are 395.1t/km^2/y,1776t/km^2/y,2115t/km^2/y, respectively, accounted for the total prey, total inflow debris are 8.26%, 20.16%, and 90.97% of the total respiration. The to34tal energy flow of trophic level III is 395.1t/km^2/y, which accounts for 1.6% of the total energy flow of the system. The energy flow of trophic levels IV to VI is relatively small, accounting for 0.35%, 0.07%, and 0.01% of the total energy flow of the system, respectively.

The flow from each integrated trophic level to the debris in the system is 8809t/km^2/y, accounting for 36.47% of the total energy flow of the system. In the total energy flow of the ecosystem, the flows from primary producers and detritus are 14666 t/km^2/y and 9481 t/km^2/y, respectively, accounting for 60.73% and 39.27%, indicating that the energy flow of the grazing food chain is slightly higher than that of the detritus food chain.

Tab.4 The total energy flow of the integrated trophic levels of the ecosystems in the sea area of Zhongjieshan Islands

unit：t/km²/y

Trophic level	Consumption by predators	Export	Flow to detritus	Respiration	Throughput
VI	0.395	0.000	1.156	1.166	2.717
V	2.714	0.000	7.218	6.752	16.68
IV	16.68	0.000	34.65	33.54	84.87
III	84.85	0.000	141.8	168.4	395.1
II	395.1	0.000	1776	2115	4286
I	4286	8221	6848	0.000	19362
sum	4786	8221	8809	2325	24148
Extracted to break cycles					2.713
Input					0.000
Total throughput					24154

Table 5. Energy flow from primary producers to different trophic levels

unit：t/km²/y

Trophic level	Consumption by predators	Export	Flow to detritus	Respiration	Throughput
VI	0.333	0.000	0.970	0.973	2.276
V	2.274	0.000	6.005	5.590	13.87
IV	13.87	0.000	28.22	27.44	69.52
III	69.51	0.000	114.1	138.3	321.9
II	321.9	0.000	1547	1837	3705
I	3705	0.000	6848	0.000	10553
sum	4113	0.000	8544	2009	14666

Table 6. Energy flow from debris into different trophic levels

unit：t/km²/y

Trophic level	Consumption by predators	Export	Flow to detritus	Respiration	Throughput
VI	0.0623	0.000	0.186	0.193	0.441
V	0.441	0.000	1.213	1.162	2.816
IV	2.815	0.000	6.431	6.100	15.35
III	15.34	0.000	27.75	30.11	73.21
II	73.20	0.000	229.5	277.8	580.6
I	580.5	8228	0.000	0.000	8809
sum	672.4	8228	265.1	315.4	9481

3.4 Analysis of mixed nutrition effect

The Ecopath model describes the nutritional relationship between the functional groups of the ecosystem through the analysis of mixed nutrition effects, and judges the impact on other functional groups through the change of the biomass of the functional groups. The positive effect means that the increase of biomass in one functional group promotes the increase in biomass of another functional group. The negative effect is the opposite, which means that the increase in biomass of one functional group has an inhibitory effect on the biomass from another functional group. The white circle reflects that the increase in biomass of the functional group has a positive or promoting effect on the biomass of another functional group, while the black circle has a negative or inhibitory effect. The larger the circle, the more significant the effect.

The mixed nutrient effect of the ecosystem in the sea area of Zhongjieshan Islands is shown in Figure 3. The mixed nutrient effect of each functional group on itself is generally negative. Detritus and phytoplankton, as primary producers, which have positive effect on almost all functional groups. Among them, phytoplankton has a more obvious positive effect on zooplankton and benthic species; small benthic animals have a significant negative effect on zooplankton, while have positive effect on the shrimps and small benthic fishes. Sepiella maindroni has obvious negative and inhibitory effects on cephalopods and small benthic fishes, mainly due to the competition relationship between Sepiella maindroni and these functional groups. It has a positive effect on Anchovy and small yellow croaker. Other piscivorous fishes have a negative effect on Large demersal fishs and other pelagic fishes

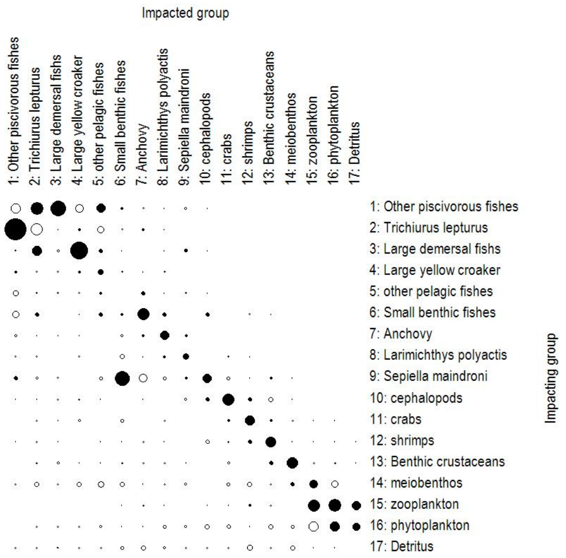

Fig.3 Mixed nutrition effects among functional groups of ecosystems in the sea area of Zhongjieshan Islands

3.5 Niche overlap analysis

The niche overlap analysis of functional groups means that in the ecosystem involved in the study, certain biological species play similar roles in the ecosystem where they are located. so the niches are relatively similar, the competition relationship is more obvious, such as similar bait species, living environment, as well as the predation habits. In the ecosystem we study, the more similar conditions the two functional groups have, the more obvious the niche overlap and the higher the value of ecological overlap. In natural environmental conditions, environmental resources are limited, so it is impossible for organisms to obtain all the food and energy they need from the environment blindly. Therefore, organisms in the ecosystem must have a competitive relationship through intra-species and inter-species competition, to obtain the required food and habitat for growth and development and reproduction of offspring. After competition, the species will inevitably lose to make concessions. By migrating to other environments and choosing to replace other organisms as food sources or choosing other time to prey, the species cross the ecological niche with the competitors to stop competition. [14-15].

The Ecopath model can calculate the food overlap index and predator overlap index between functional groups by analyzing the food web of the ecosystem in the sea area of Zhongjieshan Islands, reflecting the niche overlap between functional groups. The food overlap index indicates whether the two functional groups have similar food sources. When the value is 0, it means that the two functional groups do not have the same food source. When the value is 1, it means that the two functional groups compete fiercely for the same prey object. The predator overlap index indicates the similarity of pressure from the predator and prey between the two functional groups. A value of 0 indicates that there is no same predator, and a value of 1 indicates that the two functional groups have the same predator. The analysis result is shown in Figure 4. It can be seen from Figure 4 that cephalopods and crabs have the highest niche overlap index, and the overlap is above 0.8. The niche overlap index of Anchovy and small yellow croaker is also above 0.8. Other piscivorous fishes and Anchovy have the lowest overlap index, around 0.1.

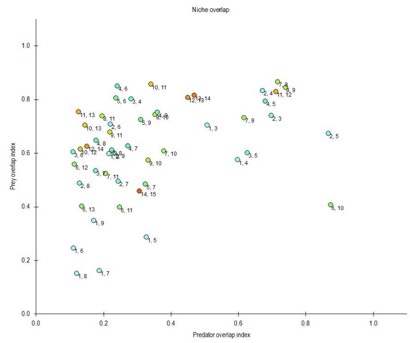

Fig.4 Analysis of Niche Overlapping of Ecosystems in the sea area of Zhongjieshan Islands

4 Conclusions

4.1 Overall characteristics of the ecosystem

Table 7 shows the total parameters of the ecosystem characteristics in the sea area of Zhongjieshan Islands after the establishment of the Ecopath model. It can be seen from Table 7 that in the current system state, the total consumption is 4786.189t/km^2·year, the total output is 8228.404 t/km^2·year, the total breathing is 2234.796t/km^2·year, and the total amount of debris flowing is 8808.951 t/km^2·year, total biomass (excluding debris) is 211.128t/km^2·year. From the model data, the sea area of Zhongjieshan Islands is rich in nutrition and bait resources, and the productivity level is at a relatively high level. When the Sepiella maindroni reaches the ecological capacity, the variation of the characteristic parameters of the ecosystem is subtle, so the ecosystem is basically stable, and the organisms of other functional groups in the sea area have no significant impact on.

Table 7. Ecosystem characteristic parameters in the sea area of Zhongjieshan Islands

parameters	Value	Units
Sum of all consumption	4786.189	t/km^2/y
Sum of all exports	8228.404	t/km^2/y
Sum of all respiratory flows	2324.796	t/km^2/y
Sum of all flows into detritus	8808.951	t/km^2/y
Total system throughput	24148.34	t/km^2/y

Sum of all production	12057.35	$t/km^2/y$
Calculated total net primary production	10553.2	$t/km^2/y$
Total primary production/total	4.539	
Net system production	8228.403	$t/km^2/y$
Total primary production/total biomass	49.985	
Total biomass/total throughput	0.009	
Total biomass (excluding detritus)	211.128	t/km^2
Connectance Index	0.478	
System Omnivory Index	0.389	

4.2 Estimation of Growth Capacity of Sepiella maindroni

To estimate the growth capacity of Sepiella maindroni in the sea area of Zhongjieshan Islands based on the Ecopath model, it is necessary to maximize the biomass of Sepiella maindroni in the Ecopath model. In order to maintain the stability of the ecosystem, the model is continuously adjusted to other functional groups. When the ecological efficiency (EE) ≥ 1, the biomass of Sepiella maindroni is the maximum ecological capacity. The maximum growth capacity is the value of the maximum ecological capacity minus the original biomass. The highest annual production of Sepiella maindroni in Zhejiang Province once reached 60,000 tons. Taking into account that the sea area of the Zhongjieshan Islands is a suitable habitat for the Sepiella maindroni, after using the sea area to estimate,

We assume that in this model, the raw biomass of Sepiella maindroni in the sea area of the Zhongjieshan Islands is 1.3 $t{\cdot}km^2$. In the model, the biomass of the Sepiella maindroni is compensated by 0.2 $t{\cdot}km^2$ based on the original data. When the biomass of the Sepiella maindroni is increased to 2.1 $t{\cdot}km^2$, the EE value of the small demersal fish in the model is 1.035, the EE values of other functional groups are all less than 1. Therefore, it can be concluded from the model that the ecological capacity of Sepiella maindroni at this time is about 2 $t{\cdot}km^2$. The specific debugging process is shown in Table8.The Zhongjieshan Islands Marine Special Protection Area covers an area of 202.9km^2. Considering that the sea area of the Zhongjieshan Islands is a suitable habitat for the Sepiella maindroni, it is estimated that the ecological capacity of Sepiella maindroni in the Zhongjieshan Islands Marine Special Reserve is 405.8t.

Table 8. The variation of the releasing capacity of Sepiella maindroni in the model

Add value $/t{\cdot}km^2$	biomass $/t{\cdot}km^2$	Change in model
0(current)	1.3	balance
0.2	1.5	balance
0.2	1.7	balance
0.2	1.9	balance
0.1	2	balance
0.1	2.1	Small demersal fish EE=1.035

5 Summary and Prospect

5.1 The main conclusions and results of this research

In this study, the sea area of the Zhongjieshan Islands was used as the research object, and the EwE6.5 version model software was used to construct the Ecopath model of the ecosystem in the sea area of Zhongjieshan Islands. According to the running results of the model, the structure and function changes of the ecosystem in the sea area of Zhongjieshan Islands are discussed, and the energy flow of the ecosystem is evaluated. Which provides guidance for the estimation of the growth capacity of Sepiella maindroni in the sea area of Zhongjieshan Islands.

The main conclusions of this study are as follows:

(1) Constructed an Ecopath model of the ecosystem in the sea area of Zhongjieshan Islands including 17 functional groups. The effective trophic level of each functional group ranges from 1-4.648. Functional groups such as shrimps, small demersal fish, pelagic fish and other functional groups have higher Ecotrophic Efficiency, while detritus, phytoplankton, zooplankton and other functional groups have lower Ecotrophic Efficiency.

(2) The total energy flow of the ecosystem in the sea area of Zhongjieshan Islands is 24154 $t/km^2{\cdot}$year. The total energy flow of the ecosystem from primary producers and debris accounted for 60.73% and 39.27% of the total energy flow of the system, respectively, which indicates that the energy flow of the grazing food chain is slightly higher than that of the detrital food chain.

(3) The TPP/TR value of the ecosystem in the sea area of Zhongjieshan Islands is 4.539; the SOI value is 0.389; the CI value is 0.478; and the TB/TT value is 0.009. In the current system status, the Sum of all consumption is 4786.189$t/km^2{\cdot}$year; the Sum of all exports is 8228.404 $t/km^2{\cdot}$year; the Sum of all respiratory flows is 2324.796$t/km^2{\cdot}$year; and the total flow of debris is 8808.951 $t/km^2{\cdot}$year. Year, the total biomass (excluding debris) is 211.128$t/km^2{\cdot}$year. From the model data, the sea area of Zhongjieshan Islands is rich in nutrition and bait resources, and the productivity level is at a relatively high level.

(4) Based on the Ecopath model analysis of the sea area of the Zhongjieshan Islands, it is concluded that the trophic level of the Sepiella maindroni in this sea area is 3.562, which belongs to the middle trophic level. The Ecotrophic Efficiency is 0.306, and the ecological capacity is 2 t·km^2.

5.2 The shortcomings and prospects of this research

(1) Ecopath is a static model. The model presents an idealized state. It only inputs data from the perspective of material energy balance to estimate the proliferation capacity, but cannot evaluate the process of biological growth. Subsequent studies can add Ecosim dynamic simulation of fishery policy and environmental changes and other parameters to evaluate the impact of observations on biomass and catches within a certain period of time, and conduct in-depth spatial analysis in conjunction with Ecospace[16].

(2) In addition, in the process of constructing the Ecopath model, some data such as gastric content analysis data, biomass data, P/B, Q/B, etc. are difficult to obtain. Therefore, in this study, we often refer to the literature of neighboring similar sea area models for data integration and reference. However, various factors such as insufficient data accuracy will lead to deviations in the model results. In subsequent studies, the data of the study area needs to be further obtained and studied, and more accurate collection of survey data of various types of operations will be considered, and various influencing factors such as climate and environment will be considered comprehensively, so as to achieve the ecological assessment of the study area. The accuracy of the analysis of the energy flow characteristics of the system further improves the accuracy and reliability of the Ecopath model.

(3) In addition, this study can also consider the habitat environment, food habits and other factors of the Sepiella maindroni to be more scientifically analyzed to improve the accuracy of the evaluation of the breeding and release effects of Sepiella maindroni. In this study, due to the incompleteness of some important basic data, such as the food matrix of some functional groups, these unknown data can only be estimated, so it will also have a certain impact on the research results. Which will also cause some errors with the actual local conditions.

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