Assessment of Marine Rescue Abilities Based on ISM and AHP as well as Fuzzy Evaluation

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Abstract. In marine accident disposal, the maritime sector of sea area's rescue abilities evaluation plays an essential role in improving emergency rescue abilities as well as optimizing the management, which can reduce similar occurrings. In this paper, Interpretative Structural Modeling(ISM) was firstly used in analyzing the correlation between assessment indicators about marine rescue abilities. Then, through the Analytic Hierarchy Process(AHP) every indicator's weight was ascertained. Finally, we assessed the rescue abilities by multi-level fuzzy comprehensive evaluation. The results can embody the degree of excellence of marine rescue abilities in waters, specifically point out the existing problems and put forward relevant suggestion according to the order of importance to lower the loss of similar marine accidents. With regard to the rescue abilities of marine or onshore emergency, this paper's research is of great theoretical and practical value.

Introduction

With the maritime transport bringing economic value, marine accidents, however, have brought serious harm to the safety of life, property safety and the environment. After the accident, the rescue capacity of the maritime department near the accident spot plays a decisive role in reducing the loss. To improve the rescue ability at sea, we can obtain the degree of excellence by evaluation, combined with the importance ranking of rescue ability indicators, to point out the problems and put forward corresponding opinions. Then, the maritime sector is to take measures based on problems and opinions to improve the marine rescue ability and reduce the loss caused by similar accidents. At present, many international scholars or departments concerned have done a lot of research on the evaluation of competency, and have achieved some results. In China, scholars such as Yang Li, Wang Lei in the coal mine emergency rescue capacity evaluating indicator system based on ISM finally obtained the coal mine emergency rescue capability evaluating indicator system model diagram by establishing the adjacency matrix and reachability matrix among the evaluating indicators of coal mine emergency rescue capability, which provides a basis for evaluating the coal mine emergency rescue capability. For multi-purpose indicators, they can also be reflected through the model diagram system, which reduces the duplication of redundant targets and highlights the selected indicators of the necessity and comprehensiveness [1]. As another example, Hu Jun Feng and others in the research on evaluating indicators system of regional integrated disaster mitigation capability established an evaluating indicator system of regional integrated disaster mitigation

capability, which can access the integrated disaster reduction capacity in a region and compare the capacity of numerical differences of a certain region in different periods [2]. FEMA and IAEM in the United States, jointly proposed the state and local government emergency response assessment system (CAR) in 1997. The system has 13 emergency management functions, each with corresponding evaluating indicators. What is more, each emergency management function is divided into several attributes, subdivided into several features respectively. Each state can assess its emergency response capability at the level of each attribute [3]. It can be seen that experts and relevant maritime institutions have had some research on disaster relief capability evaluation, but there is no mature solution for the evaluation of emergency rescue capability at sea. In allusion to the evaluation of marine rescue capability, this paper firstly uses ISM to analyze the relationship between the evaluating indicators of sea rescue capacity [4], and then determine the weight of each indicator through AHP [5]. Finally, it evaluates the rescue ability with multi-level fuzzy comprehensive evaluation. The evaluation results can be used to assess the maritime rescue ability of the maritime sector in a certain sea area, and point out the existing problems and propose corresponding opinions according to the importance ranking of the indicators to reduce the loss caused by similar accidents at sea. This program can effectively assess the rescue ability of the maritime sector with a good practicality.

Evaluation Model of Maritime Rescue Ability

Rescue capability evaluation indicator system

The evaluation indicator system of maritime rescue capability includes the indicators and their relationships.

Maritime rescue capability indicators

As is shown in Table 1, there are usually 23 indicators for assessing marine rescue abilities.

Table1 Assessment indicators of marine rescue abilities

Assessment indicators	The indicator number S_i
Emergency rescue capability	S_0
Emergency response capability	S_1
Communication management	S_2
Resource guarantee	S_3
Aid decision making	S_4
Regulation and control	S_5
Emergency measures	S_6
Time-effect of dispatch	S_7
Personnel composition	S_8
Gathering	S_9
Equipment transfer	S_{10}
Collection of transportation information	S_{11}
Salvage effect	S_{12}
First respond at the spot	S_{13}
Information consolidation at the spot	S_{14}
Comprehensive consideration and evaluation of risks and uncertain factors	S_{15}
Rapid rescue plan making	S_{16}
Efficient allocation of rescue resources	S_{17}
Unified coordination and risk control in the rescue process	S_{18}
Joint rescue	S_{19}
Command center	S_{20}
Relevant departments	S_{21}
Relevant local government	S_{22}

Confirmation of the correlation between assessment indicators

After the assessment indicators determined, the correlation between the indicators needs to be confirmed. Interpretative Structural Modeling (ISM) is a structural modeling technique proposed by J Warfield [6]. The model can be used to better determine the relationship between the assessment indicators of marine rescue ability. The specific steps are as follows:

（1）Adjacency matrix building

The influences between the assessment indicators of marine rescue ability are described by the adjacency matrix A. The element a_{ij} in A is used to express the influence between the factors, as is shown in formula（1）.

$$a_{ij} = \begin{cases} 1 & (S_i \text{ is directly related to the } S_j) \\ 0 & (S_i \text{ is not directly related to the } S_j) \end{cases} \qquad (1)$$

Through group discussing and research as well as expert consultant, we get the adjacency matrix A of the marine rescue ability indicators, as is shown in Table 2.

Table2 Adjacency matrix A

	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	S_{19}	S_{20}	S_{21}	S_{22}
S_0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_2	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
S_3	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
S_4	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_5	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_6	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_7	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_8	1	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
S_9	1	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
S_{10}	1	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
S_{11}	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
S_{12}	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
S_{13}	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
S_{14}	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0
S_{15}	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0
S_{16}	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
S_{17}	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
S_{18}	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
S_{19}	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S_{20}	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1
S_{21}	1	1	0	0	1	1	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1
S_{22}	1	1	0	0	1	1	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1

（2）Reachable matrix building

The degree to which a certain path through each node in a directed graph can be reached is described by the reachable matrix M. Since the adjacency matrix A belongs to the Boolean matrix, we use the Boolean matrix algorithm to calculate the reachable matrix:

$M=(A+I)^k=(A+I)^{(k-1)}\neq(A+I)^{(k-2)}\neq\cdots(A+I)$ $(k\leq n-1)$ (2)

The reachability matrix M represents all the direct and indirect relationships between each of the rescue ability indicators.

（3）Hierarchy chart building

In the reachable matrix M, we establish the reachable set R (S_i), which means that the indicator S_i can reach all the indicators of the set, then sum up the direct impact of the indicators; A（S_i）denotes the set of all indicators that can reach the index S_i, and sums up the affected relationship

among the indicators; Let $C(S_i) = R(S_i) \cap A(S_i)$ represent the indicator having interference with S_i. The R（S_i）, A（S_i）and C（S_i）of the reachable matrix M are shown in Table 3.

Table3 R(Si)、 A（Si）and C（Si）of reachable matrix M

S_i	$R(S_i)$	A （S_i）	C （S_i）
0	0	All included	0
1	0,1	1,2,3,4,5,6,8,9,10,13,14,15,16,17,20,21,22	1
2	0,1,2,3,4,5,6,7,8,11,12,17	2	2
3	0,1,3,4,5,6,7,8,12,17	2,3	3
4	0,1,4,7	2,3,4,20,21,22	4
5	0,1,5,7,8,12	2,3,5,20,21,22	5
6	0,1,6,7,8,12	2,3,6	6
7	0,7	2,3,4,5,6,7,8,9,10,11,20,21,22	7
8	0,1,7,8,12	2,3,5,6,8,20,21,22	8
9	0,1,7,9,12	9	9
10	0,1,7,10,12	10	10
11	0,7,11,12	2,11	11
12	0,12	2,3,5,6,8,9,10,11,12,13,14,15,16,17,18,20,21,22	12
13	0,1,12,13	13	13
14	0,1,12,14,15,16,18	14	14
15	0,1,12,15,16,18	14,15	15
16	0,1,12,16	14,15,16,20,21,22	16
17	0,1,12,17	2,4,17,20,21,22	17
18	0,12,18	14,15,18,20,21,22	18
19	0,19	19,20,21,22	19
20	0,1,4,5,7,8,12,16,17,18,19,20,21,22	20,21,22	20
21	0,1,4,5,7,8,12,16,17,18,19,20,21,22	20,21,22	21
22	0,1,4,5,7,8,12,16,17,18,19,20,21,22	20,21,22	22

After the highest-level indicator elements set confirmed, we remove the corresponding rows and columns in the matrix, and then seek the new highest-level elements from the remaining. And so on, the highest-level elements set included in each level are able to be found [7]. Results:

L1={S_0} （3）L2={S_1,S_7,S_{12},S_{19}} （4）

L3={S_4,S_8,S_9,S_{10},S_{11},S_{13},S_{16},S_{17},S_{18}} （5）L4={S_5,S_6,S_{15}} （6）

L5={S_3,$S_{14,}$ S_{20},S_{21},S_{22}} （7）L6={S_2} （8）

According to the classification of Li, confirm the connection between the higher level indicators and the lower level indicators combined with reachable matrix, so as to establish the interpretive structural model of marine emergency response abilities assessment indicators in Figure 1.
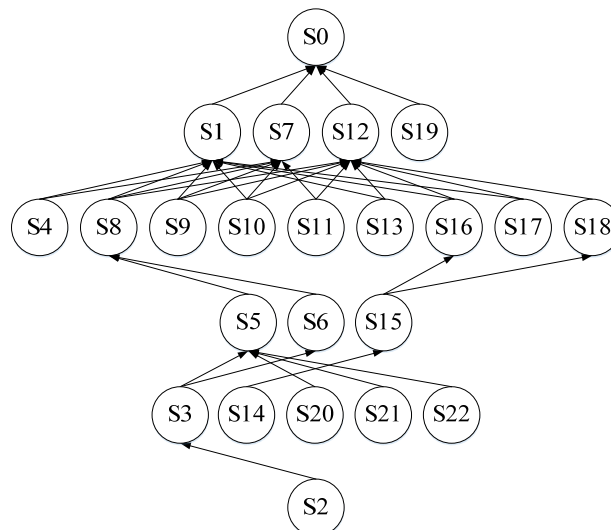

Fig.1 Interpretive structural model of marine emergency response abilities assessment indicators

Analysis of the impact of emergency rescue ability indicators

To improve relatively important indicators, is an important approach to quickly and effectively improve the ability of emergency rescue at sea [8]. Because of the large number of emergency rescue ability indicators, the AHP method is used to rank the important indicators, and then we can

identify and select the indicators that have a greater impact on the emergency rescue ability. AHP is a systematic engineering method proposed by T. L. Saaty in the 1970s. It combines people's subjective judgment to transfer qualitative analysis into quantitative analysis, thus simplifying the complex system, making it into the paired comparison and simple calculations.

Pairwise comparison matrix building

According to the indicator system using ISM, the relative importance of peer indicators is compared by expert scoring. As Table 4 depicts, $S_{i,j}$ represents the importance of indicator S_i relative to S_j, the value in accordance with scale 1 to 9. On this basis, we establish the judgment matrix. The first and seventh indicators are not compared for being individual indicators with weight set to 1. Table 5 (a) - (d) shows the pairwise comparison matrix of the secondary to fifth class indicators.

$S_{i,j}$	Interpretation
1	S_i, S_j are of equal importance
3	Compared with S_j, S_i is of weak importance
5	Compared with S_j, S_i is of strong importance
7	Compared with S_j, S_i is of very strong importance
9	Compared with S_j, S_i is of absolute importance

（Note: 2, 4, 6, 8, respectively represents the mid-value of the two adjacent standard values.）

Table4 Relative importance of indicators at the same level

	S_1	S_7	S_{12}	S_{19}
S_1	1	1/2	1	3
S_7	2	1	1	5
S_{12}	2	1	1	5
S_{19}	1/3	1/5	1/5	1

Table5（a）

	S_4	S_8	S_9	S_{10}	S_{11}	S_{13}	S_{16}	S_{17}	S_{18}
S_4	1	1/2	1/5	1/5	2	1/5	1/3	2	1
S_8	2	1	1/2	1/2	4	2	1	4	2
S_9	5	1/2	1	1	9	1	2	8	5
S_{10}	5	1/2	1	1	9	1	2	9	6
S_{11}	1/2	1/4	1/9	1/9	1	1/9	1/6	1	1/2
S_{13}	5	1/2	1	1	9	1	2	9	5
S_{16}	3	1/2	1/2	1/2	6	1/2	1	5	3
S_{17}	1/2	1/4	1/9	1/9	1	1/9	1/5	1	1/3
S_{18}	1	1/2	1/5	1/6	2	1/5	1/3	3	1

Table5（b）

	S_5	S_6	S_{15}
S_5	1	5	2
S_6	1/5	1	1/3
S_{15}	1/2	3	1

Table5（c）

	S_3	S_{14}	S_{20}	S_{21}	S_{22}
S_3	1	2	1/3	1/2	2
S_{14}	1/2	1	1/9	1/5	1
S_{20}	3	9	1	2	6
S_{21}	2	5	1/2	1	5
S_{22}	1/2	1	1/6	1/5	1

Table5（d）

Table5 Pairwise comparison matrix of indicators at different levels

Weight calculation

Calculate the eigenvectors of each grade in pairwise comparison matrix, and normalize to get weight vector Wi=（W1，W2，…, Wn），Wn, the weight corresponding to indicator n. Check consistency. If the random conformance rate CR≦0.1, then the consistency check is passed. The weights at different levels confirmed are as follows:

Second class indicator: the largest eigenvalue X=4.23078, coincidence indicator CI=0.07693, random conformance rate CR=0.08643＜0.1, pass the consistency check. Weight vector W2=（0.2109 0.3388 0.3388 0.0647）.

Third class indicator: the largest eigenvalue X=9.04844, coincidence indicator CI=0.00606, random conformance rate CR=0.00415＜0.1, pass the consistency check. Weight vector W3=（0.0070 0.0555 0.1520 0.1639 0.0014 0.1566 0.0473 0.0014 0.0067）.

Fourth class indicator: the largest eigenvalue X=3.00369, coincidence indicator CI=0.00185, random conformance rate CR=0.00355＜0.1, pass the consistency check. Weight vector W4=（0.5179 0.1480 0.3223）.

Fifth class indicator: the largest eigenvalue X=5.03142, coincidence indicator CI=0.00785, random conformance rate CR=0.00701＜0.1, pass the consistency check. Weight vector W5=（0.1181 0.0424 0.5544 0.2922 0.0470）.

Multi-level fuzzy comprehensive evaluation

The decision-making and rescue of emergency rescue at sea involves the influence of multiple indicators and the coordination assistance of multiple departments, which is a complex fuzzy system. With indicators classified, it is possible to build a multi-level fuzzy comprehensive evaluation model based on the structural model using the ISM and the indicator weight obtained by the AHP. The model can be applied to the evaluation of the rescue capability of a marine emergency rescue unit.

Basic principle of fuzzy comprehensive evaluation

Suppose the set of evaluation indicators is U, establish a multi-level indicator set based on the structure model:

$$U = \{U_1(S_1,S_7,S_{12},S_{19})\} \quad (9) \qquad U = \{U_1(S_4,S_8,S_9,S_{10},S_{11},S_{13},S_{16},S_{17},S_{18})\} \quad (10)$$

$$U = \{U_1(S_5,S_6,S_5)\} \quad (11) \qquad U = \{U_1(S_3,S_{14},S_{20},S_{21},S_{22})\} \quad (12)$$

Establish a goal set of marine emergency rescue ability indicators [9]:

V=｛Excellent Good Average Up to the standard Poor ｝

Excellent represents that the indicator can dramatically improve marine emergency rescue ability. And so forth, poor represents that the indicator deteriorate emergency ability.

According to the evaluation indicator system of marine emergency rescue ability, the weight of each indicator is determined by AHP, the multi-level fuzzy evaluation model is established with the membership function, and the emergency rescue capability of a specific marine emergency rescue unit is evaluated synthetically. The synthetic algorithm of fuzzy comprehensive evaluation is shown as formula (13):

$$B = W \circ R \qquad (13)$$

In the formula: W is the weight vector of the weights of the evaluation indicators of the marine emergency rescue ability determined by the AHP; R is the fuzzy relation matrix; B denotes the fuzzy comprehensive evaluation matrix of the grade; "∘" is synthesis operator, take $M(\bullet,\oplus)$：• is defined as $a \bullet b = a \times b = ab$; $\oplus$ is defined as $a \oplus b = (a+b) \wedge 1$.

The final evaluation matrix of the fuzzy comprehensive evaluation model is obtained by evaluating each indicator according to the goal. According to the principle of maximum degree of membership, the evaluation grade of maximum membership in fuzzy comprehensive evaluation matrix is the final evaluation result.

The Determination of membership of each indicator

The goal set of a certain indicator is described by the membership function. Since the index set of comments is divided into five levels, meanwhile taking into account the way of marking, the isosceles triangle membership function is adopted. The mathematical description of the membership of ith indicator is shown in (14).

$$r_i(v_k) = \begin{cases} \dfrac{s_i - m_k}{n_k - m_k}, & m_k \leq s_i \leq n_k \\ \dfrac{p_k - s_i}{s_i - n_k}, & n_k \leq s_i \leq h_k \\ 0, & other \end{cases}$$

（14）

In the formula: mk, nk, pk is the constant corresponding to k-th evaluation level. The standardized indicators are corresponding to the goals: $n_1 = 0, n_2 = 0.25, n_3 = 0.5, n_4 = 0.75, n_5 = 1$. To ensure that each indicator can get at least four reviews of membership, take the base of isosceles triangle of 1.6. Thus the five membership functions are as follows:

$$r_i(v_1) = \begin{cases} \dfrac{s_i - 0.2}{0.8}, & 0.2 \leq s_i \leq 1 \\ 0, & other \end{cases}$$

（15）

$$r_i(v_2) = \begin{cases} \dfrac{s_i + 0.05}{0.8}, & 0 \leq s_i \leq 0.75 \\ \dfrac{1.55 - s_i}{0.8}, & other \end{cases}$$

（16）

$$r_i(v_3) = \begin{cases} \dfrac{s_i + 0.3}{0.8}, & 0 \leq s_i \leq 0.5 \\ \dfrac{1.3 - s_i}{0.8}, & 0.5 \leq s_i \leq 1 \end{cases}$$

（17）

$$r_i(v_4) = \begin{cases} \dfrac{s_i + 0.55}{0.8}, & 0 \leq s_i \leq 0.25 \\ \dfrac{1.05 - s_i}{0.8}, & 0.25 \leq s_i \leq 1 \end{cases}$$

（18）

$$r_i(v_5) = \begin{cases} \dfrac{0.8 - s_i}{0.8}, & 0 \leq s_i \leq 0.8 \\ 0, & other \end{cases}$$

（19）

Therefore, the fuzzy relation matrix R_q of level q is shown as formula (20).

$$R_q = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}$$

（20）

Comprehensive evaluation result of marine emergency rescue ability

After the membership of each index determined, based on the basic principle of multi-level fuzzy comprehensive evaluation, the comprehensive evaluation result of the marine emergency rescue ability is shown in formula (21).

$$B = W \circ R = (w_2, w_3, w_4, w_5, w_6) \circ \begin{pmatrix} W_2 \circ R_2 \\ W_3 \circ R_3 \\ W_4 \circ R_4 \\ W_5 \circ R_5 \\ W_6 \circ R_6 \end{pmatrix} = (b_2, b_3, b_4, b_5, b_6)$$

（21）

In the formula: the weight of each level calculated by AHP is: w_2, w_3, w_4, w_5, w_6 =0.4418， 0.2351， 0.1509， 0.0900， 0.0822， CR=0.0086.

Case analysis

Taking the assessment of marine emergency rescue abilities of an emergency rescue department in Bohai Bay as an example, the experts' scoring method was used to score the emergency rescue abilities evaluation indicators of the department. Score interval is set to 1-100, the higher the score the better the indicator. The specific scores are shown in Table 6.

Table6 Indicators scoring about the emergency rescue abilities assessment

Assessment indicators	Score
Emergency response capability S_1	81
Communication management S_2	91
Resource guarantee S_3	13
Aid decision making S_4	91
Regulation and control S_5	63
Emergency measures S_6	10
Time-effect of dispatch S_7	28
Personnel composition S_8	55
Gathering S_9	96
Equipment transfer S_{10}	96
Collection of transportation information S_{11}	16
Salvage effect S_{12}	97
First respond at the spot S_{13}	96
Information consolidation at the spot S_{14}	49
Comprehensive consideration and evaluation of risks and uncertain factors S_{15}	80
Rapid rescue plan making S_{16}	14
Efficient allocation of rescue resources S_{17}	42
Unified coordination and risk control in the rescue process S_{18}	92
Joint rescue S_{19}	79
Command center S_{20}	96
Relevant departments S_{21}	66
Relevant local government S_{22}	4

The scores of indicators of each level are normalized by min-max method, and the standardized evaluation matrix is obtained as shown in formula (22) - (27).

$$C'_{ij} = \frac{C_{ij} - C_{i\max}}{C_{i\max} - C_{i\min}} \qquad （22）$$

$$C'_2 = \begin{bmatrix} 0.77 & 0 & 1 & 0.74 \end{bmatrix} \qquad （23）$$

$$C'_3 = \begin{bmatrix} 0.94 & 0.50 & 1.00 & 1.00 & 0.02 & 1 & 0 & 0.34 & 0.95 \end{bmatrix} \qquad （24）$$

$$C'_4 = \begin{bmatrix} 0.76 & 0 & 1 \end{bmatrix} \qquad （25）$$

$$C'_5 = \begin{bmatrix} 0.10 & 0.49 & 1 & 0.67 & 0 \end{bmatrix} \qquad （26）$$

$$C'_6 = \begin{bmatrix} 1 \end{bmatrix} \qquad （27）$$

In the formula: C_{ij} represents the jth indicator in level i, $C_{i\min}$, $C_{i\max}$ represent the lowest score and highest score in level i. According to (15) - (19), the fuzzy evaluation matrix R_i of indicator of each level is shown as (28) - (32).

$$R_2 = \begin{bmatrix} 0.71 & 0.98 & 0.66 & 0.35 & 0.04 \\ 0.00 & 0.06 & 0.38 & 0.69 & 1.00 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \\ 0.68 & 0.93 & 0.70 & 0.39 & 0.08 \end{bmatrix} \qquad （28）$$

$$R_3 = \begin{bmatrix} 0.92 & 0.76 & 0.45 & 0.14 & 0.00 \\ 0.38 & 0.69 & 1.00 & 0.69 & 0.38 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \\ 0.00 & 0.09 & 0.41 & 0.72 & 0.97 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \\ 0.00 & 0.06 & 0.38 & 0.69 & 1.00 \\ 0.18 & 0.49 & 0.80 & 0.89 & 0.57 \\ 0.94 & 0.75 & 0.44 & 0.12 & 0.00 \end{bmatrix} \qquad （29）$$

$$R_4 = \begin{bmatrix} 0.70 & 1.00 & 0.68 & 0.37 & 0.05 \\ 0.00 & 0.06 & 0.38 & 0.69 & 1.00 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \end{bmatrix} \qquad （30）$$

$$R_5 = \begin{bmatrix} 0.00 & 0.18 & 0.50 & 0.81 & 0.88 \\ 0.36 & 0.67 & 0.99 & 0.70 & 0.39 \\ 1.00 & 0.69 & 0.38 & 0.06 & 0.00 \\ 0.59 & 0.90 & 0.78 & 0.47 & 0.16 \\ 0.00 & 0.06 & 0.38 & 0.69 & 1.00 \end{bmatrix} \qquad （31）$$

$$R_6 = \begin{bmatrix} 0.89 & 0.80 & 0.49 & 0.18 & 0.00 \end{bmatrix} \qquad （32）$$

On the basis of AHP, we obtain the index weighting vector and the rank weighting vector. Fuzzy

computing according to （15）-（21）：

B=[0.5970 0.5611 0.4246 0.2718 0.2178]

It is seen that the salvage capability of the marine emergency rescue unit is excellent for taking timely and appropriate rescue operations to meet most of the emergency rescue requirements. For further optimization, the indicator is to be analyzed step by step according to the structural model obtained by ISM and the importance ranking of the indicators obtained by AHP, improved targeted. First, we analyze the second class indicator. From Table 3 we see that the time-effect of dispatch is poor. Its corresponding subordinate indicators personnel composition and collection of transportation information are poor. By further analysis of subordinate indicators, we see the corresponding indicators regulation and control as well as emergency measures are poor. Corresponding indicator resource guarantee and relevant local government are poor. In conclusion, the department can improve cooperation with local departments, allocate the rescue personnel reasonably, and enhance the ability of transportation information collection, so as to effectively reduce the dispatch time, enhance efficiency and improve its rescue ability.

Conclusions

The degree of excellence is got through the evaluation of maritime rescue ability. Next, combined with the importance ranking of the rescue to point out the problems and make corresponding comments. On this basis, the maritime sector is able to take corresponding measures which can greatly improve the marine rescue ability to reduce the loss caused by accidents. For marine rescue ability evaluation, in this paper, we first use ISM to analyze the interaction between the assessment indicators of maritime rescue ability, and then determine the weight vector of each indicator by AHP, then use multi-level fuzzy evaluation to evaluate the rescue ability [10]. The evaluation results can reflect the degree of excellence of marine rescue ability of a certain maritime department. In order to verify the practicability of this model, we take the evaluation of marine rescue ability in a certain area of Bohai Bay as an example to analyze. The results prove that the model can effectively assess the excellence degree of marine rescue ability with good practicability. The model constructed in this project has reference significance for other similar ability evaluation problems.

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