Studies on evaluation index system for the canvas stow net operation performance via the vague APH method

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Abstract. Based on the questionnaire data of specialist, the first level and second level index and respective weight distribution of evaluation index system for canvas stow net operation performance were obtained. The weight of index was adjusted through consistency judgment for assuring the rationality of index weigh. Evaluation index system was established based on the above mentioned studies, and the reference basis was provided for the evaluation of canvas stow net operation performance in the future. Based on the questionnaire data of fishery experts, in this studies, the vague APH method was used to determine the first and second level index of the performance evaluation system of canvas stow net and the corresponding weight, the index weight through the consistency test was adjusted to ensure the rationality of the index weight of the evaluation system. On the basis of the above, a performance evaluation model was built, which can provide reference and basis for future performance evaluation.

1. Introduction

There is a long coastline and many fishing grounds with abundant biological resources in our country, which promotes the development of stow net. Stow net is an important fishing gear in coastal and inland waters, which occupies a certain proportion of the catch and has good economic benefits. Due to the passivity and filter-ability, the overall mesh size is small and the selectivity is bad. It is not conducive to the target escape and resources protection. The evaluation of the stow net operation performance are formulated and the evaluation system is constructed in order to grasp the basic situation and operation[1].

Peng et al. measured the effect of flow velocity on the stow net performance by model test, and observed the relationship between net parameters and operation[2]. Through a series of flume experiments, Huang H.L.[3-4] and Cheng J.H.[5] studied the influence of canvas structural parameters on its performance. The relationship between the net curvature and the resistance was established. The influence of the canvas expansion on the performance was discussed, and the different specifications canvas were also discussed. The selectivity test of net bag was carried out, and the selectivity performance was analyzed and summarized, the suitable mesh size of net bag in the East China Sea was attempted to be given. Zhang J.[6] and others have carried out selective experiments on various stow net models, compared the accuracy of each selective model, and discussed the influence of model parameters on selectivity. Li G.C.[7] and others analyzed the diversity characteristics of the structure
and composition of the catch species based on the survey data, and concluded that the species of the catch were more diverse, but the proportion of juvenile fish remained high, which was not conducive to the regeneration and sustainability of resources.

Most of the existing performance evaluation results are based on flume experiments and numerical simulation, concentrate on the performance and structural parameters of the net, or its selectivity, fishing capacity and composition of catches. The results are mostly limited characteristics, lack of overall research, especially the evaluation of operation performance.

Because the performance evaluation of canvas stow net operation is a multi-level, multi-factor, wide-ranging and standard-ambiguous research problem, and the fuzzy hierarchical comprehensive evaluation decision-making strategy is a very effective multi-factor decision-making method to make a comprehensive evaluation of the things affected by many factors. It can not only evaluate the object according to the size of the comprehensive score. Evaluation and ranking can also evaluate the level of the object, so the method of vague APH method is chosen as the analysis method. In this paper, canvas stow net is selected, and the evaluation index system and model of canvas stow net operation performance are established by scoring fishery experts questionnaires and statistic scores.

2. Materiel and method

2.1. Data sources

In the evaluation of canvas stow net, resource, economic and safety factors are very important evaluation index. After consultation with fishery experts, the three factors are selected as the first level index, and the initial second level index of each first level index are listed. Questionnaires are distributed to five fishery experts and scored for analysis.

2.2. Method

The membership degree of the second level index of fishery expert choice, and the index option with higher membership degree is retained. The index weight is determined by taking the average value of the index weight percentage given by the experts. The analytical methods are as follows: The degree to which elements belong to a set is called membership degree. In this study, we select the universe \( U \), let \( u_0 \in U \), consider a set \( A^* \), which is a movable boundary of \( u \), and then \( u_0 \) belongs to \( A^* \). The membership degree of \( u_0 \) is as follows:

\[
\mu(u_0) = \lim_{n \to \infty} \frac{\text{times of } (u_0 \in A^*)}{n}
\]  

As long as \( n \) is large enough, it can be determined that the element belongs to the set. In this paper, select \( n=3 \), that means, half of the experts think that the secondary index should be retained and subordinate to the evaluation system of this paper.

2.3. Consistency test

In order to test the consistency of the weight matrix, the key point of matrix consistency which is the consistency rate CR, the larger the CR value is, the worse of the consistency is obtained. In this study, the \( \varepsilon = 0.1 \) is set. If the consistency index satisfies the condition of \( CR \leq \varepsilon \), the matrix has satisfactory consistency, contrarily the weight matrix does not satisfy the consistency requirement, then we need to adjust the matrix factor to achieve it. According to the criteria of consistency test, the consistency judgment matrix needs to be determined firstly, and the method to determine the scale of the judgment matrix is shown in Table 1.

The index weight of the final evaluation system can be obtained by consistency test, and the evaluation object can be analyzed by the system.
Table 1. Scale of consistency judgment matrix

| Scale | Definition                                      |
|-------|------------------------------------------------|
| one   | the two elements are the same important         |
| three | the former is a little bit more important than the latter |
| five  | the former is obviously more important than the latter |
| seven | the former is strongly more important than the latter |
| nine  | the former is extremely more important than the latter |
| two, four, six, eight | the median value of two adjacent judgement |
| reciprocal | the judgement of the former compares with the latter is $a_{ij}$, the judgement of the latter compares with the former is $a_{ji}=1/a_{ij}$ |

3. Results

3.1. Establishment of index and weight of evaluation system

Questionnaires were sent out to five experts, index weight were sorted out, weight matrix was obtained on average, consistency test was carried out, normalized weight vector was adjusted, and evaluation system was constructed. Consistency test was carried out, and $P = 0.045 < 0.1$, which satisfied the consistency and the weight matrix did not need to be adjusted. Finally, the indexes and weights of the performance evaluation system of the canvas stow net operation are shown in Table 2.

Table 2. Index and weight distribution of evaluation index system for the canvas stow net operation performance

| first level index | Name | Weight($W_1$) | Second level index | Name | Weight($W_2$) | Combination weight ($W_i$) |
|-------------------|------|---------------|--------------------|------|---------------|---------------------------|
| Economy index     | vessel cost            | 0.05          |                    | 0.01           |
|                   | netting gear cost      | 0.05          |                    | 0.01           |
|                   | fuel cost              | 0.26          |                    | 0.052          |
|                   | employee salary        | 0.26          |                    | 0.052          |
|                   | production value       | 0.33          |                    | 0.066          |
|                   | allowance              | 0.05          |                    | 0.01           |
|                   | size of net bag and mesh | 0.50    |                    | 0.36           |
|                   | major measure of netting gear | 0.12 | | 0.0864 |
| Resource index    | assistant catch ratio | 0.18          |                    | 0.1296         |
|                   | netting gear amount per vessel | 0.05 | | 0.036 |
|                   | working vessel number  | 0.06          |                    | 0.0432         |
|                   | working time per whole year | 0.09 | | 0.0648 |
|                   | shipping safety        | 0.06          |                    | 0.0048         |
|                   | operation safety       | 0.36          |                    | 0.0288         |
| Safety index      | equipment safety       | 0.13          |                    | 0.0104         |
|                   | seamen quality         | 0.37          |                    | 0.0296         |
|                   | property safety        | 0.08          |                    | 0.0064         |

3.2. Application Method of Evaluation System

When applying the evaluation system to evaluate canvas stow net evaluation, the evaluation is divided into four categories: $V = \{\text{excellent, good, qualified, unqualified}\}$. Through consultation from expert, 100-90 is classified as excellent, 89-75 is classified as good, 74-60 is classified as qualified, 59-0 is classified as unqualified. The rating vector $H = \{1,0.8,0.5,0.3\}$ is obtained by quantifying the rating of the evaluation with a 1-point system\[12\].
Choose an evaluation group: each member evaluates stow net performance according to second level index, score the number of people from each rating grade. Taking the number of people in each grade as a molecule and the total number of experts as denominator, the evaluation vector is obtained. 

For example, the evaluation has 1 excellent grades, 1 good grades, 3 qualified, and the rest is 0, the evaluation vector is \( \{0.2, 0.2, 0.6, 0\} \).

By multiplying the evaluation vector with the corresponding weight matrix of the evaluation system, the first-level evaluation vector \( B \) can be obtained. According to the principle of maximum membership degree\(^{(12)}\): \( \max(b_i)=b_k \), the evaluation grade will be evaluated as \( b_k \). Further calculation of the comprehensive evaluation score: According to the selected evaluation vector, \( H=\{1, 0.8, 0.5, 0.3\} \), after weighted average of the comprehensive evaluation result \( B \), the total score \( M \) can be obtained, and the evaluation object can be ranked by the score.

\[
M = B \cdot H^T = (h_1, \cdots, h_n) \cdots \\
\begin{bmatrix}
  h_1 \\
  \vdots \\
  h_n
\end{bmatrix}
\] (2)

4. Discussion

In the future, we can establish a special evaluation system for different types of stow net, and integrate the evaluation systems to develop the evaluation system software of stow net. Or compare the stow net fishing gear with trawl, purse seine and other different operation types of net, expand the scope of application of the evaluation system, and provide a better basis for the admission of fishing gear and the establishment of standards.

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