Investment Decision of Small-Scale Fishing Companies in Scotland Based on Regression Analysis Prediction Method

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Abstract. Rising sea temperatures and migration of fish under the influence of global warming have affected the returns on investment for small-scale fishing companies in Scotland. Rational investment decisions for small-scale fisheries companies over the next 50 years are an effective means of avoiding losses. First, we use MATLAB to analyze changes in sea surface temperature over the past 20 years through the OISST dataset. The similarity distance algorithm is used to predict the seawater temperature in the next 50 years. Secondly, by establishing regression analysis prediction model, the correlation between the position of the two fish schools, sea surface temperature and time are analyzed, in order to predict the future migration position of the two fish. Finally, due to the uncertainty of the costs and benefits of small-scale fisheries, we use the real option value method to calculate the total investment value of different decision-making options. We determine the best options for investment decisions by calculating the total investment value.

Keywords: Similarity Distance Algorithm · Regression Analysis Prediction Method · Real Option Value Method

1 Introduction

Global ocean temperatures affect the quality of habitats for certain ocean-dwelling species. When temperature changes are too great for their continued thriving, these species move to seek other habitats better suited to their present and future living and reproductive success. One example of this is seen in the lobster population of Maine, USA that is slowly migrating north to Canada where the lower ocean temperatures provide a more suitable habitat. This geographic population shift can significantly disrupt the livelihood of companies who depend on the stability of ocean-dwelling species.

This is also happening in Scotland. There are a lot of herring and mackerel living in the sea near Scotland. They not only make a great contribution to the Scottish fishery economy, but also play an extremely important role in the local ecology [1–3]. If the global sea surface temperature continues to rise, making herring and mackerel unable to survive in Scottish waters, they will choose to migrate, which has a great impact on small

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fishing companies that rely on these two fish for profit. In order to solve the economic crisis that these small fishing companies may encounter in the future, it is necessary to make a correct investment decision in the case of two types of fish migration.

2 Analysis Prediction Model

2.1 Seawater Surface Temperature Prediction Model

Since the similarity analysis and prediction method has a better prediction effect on the sea surface temperature, we choose to design this method on the basis of the similarity deviation algorithm [4, 5]. First determine the year and date to be forecasted, and select the latitude and longitude range of the area to be forecasted on the map. For each grid point in the range, take the temperature for a certain length of time before the forecast date as the predictor variable, and compare the predictor variable with data for the same length of time in history. Then choose the similarity distance to get the similarity of historical years.

Then we use the similarity degree method as the similarity criterion of similar analysis and forecasting methods to construct a point-by-point similarity forecast model for sea surface temperature [6, 7].

Taking a single grid point in the forecast area as an example, use D to represent the daily sea temperature data set of all historical years at this grid point:

$$D = (D_1, D_2, \cdots, D_n) \tag{1}$$

D_i——Data for the $i + 1998$ year in the sea temperature sample data.

$$D_i = (d_{i1}, d_{i2}, \cdots, d_{im}) \tag{2}$$

d_{im}——The temperature data value of the m day in the $i+1998$ year, where i = 1, 2, ... n. $i = 1, 2, \ldots n$

We use $R_{ij}(y)$ to indicate the similarity between the forecasted year (denoted as j) and the calculated similarity of the data in the same time period in each historical year (denoted as i), as shown below:

$$R_{ij}(y) = \frac{X_{ij}(y) + P_{ij}(y)}{2} \tag{3}$$

among them:

$$X_{ij}(y) = \frac{1}{M}\sum_{k=1}^{M}\left|d_{ij}(k) - e_{ij}(y)\right| \tag{4}$$

$$P_{ij}(y) = \frac{1}{M}\sum_{k=1}^{M}\left|d_{ij}(k)\right| \tag{5}$$

$$d_{ij}(k) = d_{ik} - d_{jk} \tag{6}$$

Similarity divergence algorithm:	//Calculate the similarity between samples x and y
input:x(nodes),y(nodes)	//Nodes is the number of selected temperature field lattice points
output： The similar divergence between two temperature fields Begin 1:fori=1,nodes 2:Take the sum of the differences between the two samples, e 3:The sum of the absolute values of the sum of the differences between the two samples, W 4:Find the sum of the dispersion between two samples	
5： （S+W)/2	//x,yThe similar divergence of the current lattice point between two samples

Fig. 1. Similarity deviation algorithm.

$$e_{ij}(y) = \frac{1}{M}\sum_{k=1}^{M} d_{ij}(k) \tag{7}$$

among them:

M——the relatively similar total length of days.

k——the k day in a relatively similar time series sample.

y——the index of a certain year in the historical year. For example, $y = 1$ means that the data of 1998 and forecast year are currently being calculated.

e_{ij}——the total average value of the difference between the two temperature samples in the similar time period selected in the historical year and the forecasted year.

P_{ij}——the average value of the absolute distance between the historical year data and the temperature sample data of the forecasted year, called the value coefficient.

X_{ij}——the degree of dispersion of the $d_{ij}(k)$ to e_{ij} difference between the historical year temperature sample data and the forecasted year temperature sample data, called the shape coefficient.

In general, the average value of the value coefficient and the shape coefficient is used as the similarity distance. The similarity distance algorithm is shown in Fig. 1.

After comparing the similarity distances through the algorithm, the similarity distance set C(n) between the historical temperature data and the temperature data of the forecasted year is obtained. Through the similarity degree algorithm, we predict the ocean surface temperature from 2045 to 2054, as shown in Fig. 2.

2.2 Regression Analysis Prediction Model

The correlation coefficient is calculated to indicate the close degree of linear correlation between time and the fish position variable. The calculation formula of the correlation

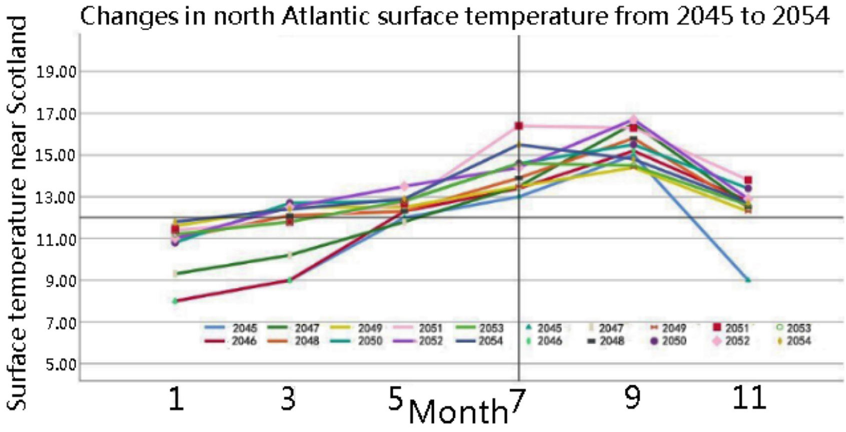

Fig. 2. Forecast results of ocean surface temperature from 2045 to 2054.

coefficient is as follows:

$$r = \frac{\sum (X - \overline{X})(Y - \overline{Y})}{n\delta_x \delta_y} \tag{8}$$

among them:

$$\delta_x = \sqrt{\frac{\sum (X - \overline{X})^2}{n}} \tag{9}$$

$$\delta_y = \sqrt{\frac{\sum (Y - \overline{Y})^2}{n}} \tag{10}$$

among them:

r——correlation coefficient.
X——time.
$\overline{X}$——average time.
Y——the relative position of the fish school.
$\overline{Y}$——the average value of the relative position of the fish school.
δ_x——the standard deviation of the time series.
δ_y——the standard deviation of the relative position of the fish school.
n——number of observations.

The degree of relevance is generally divided into four levels:
$|r| < 0.3$ is not relevant.
When $0.3 < |r| < 0.5$, it is low correlation.
When $0.5 < |r| < 0.8$, it is significantly correlated.
When $|r| > 0.8$, it is highly correlated.

According to the OISST dataset and relevant data from the "Scottish Government" network, https://www.gov.scot/, we can obtain the relationship between the position of the fish school, the time, and the surface temperature of the sea, as shown in Fig. 3.

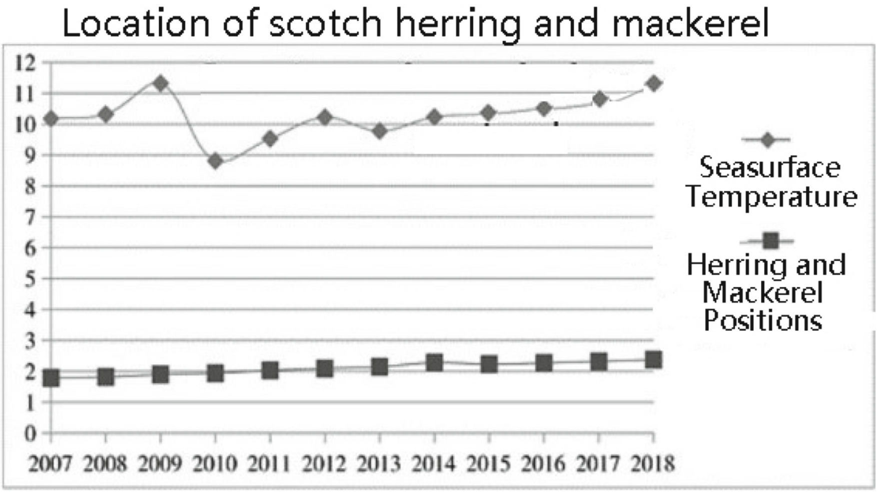

Fig. 3. The relationship between the relative positions of herring and mackerel schools, sea surface temperature and time.

According to our above classification, the correlation coefficient is $r = 0.979$, implying that the position of the fish school is highly correlated with time.

2.3 Fishery Investment Decision Model

In Scotland, most of the aquatic economic sources are herring and mackerel, which lead to uncertainties in the costs and benefits of small fishing companies. The net present value method commonly used in the conventional sense has certain limitations in its application. When there are more uncertain conditions, there is a large deviation in the evaluation of the true value. The real option value method takes into account the uncertain factors, and considers the manager's decision value factors, which can estimate the decision real option value [8]. Therefore, we use the real option value method to calculate the total investment value of different decision-making options to make fishery investment decisions.

The net present value of the fishery investment income calculation cycle is:

$$NPV = \sum\nolimits_{t=1}^{n} \frac{CF_t}{(1+r)^t} \tag{11}$$

among them:

NPV——net present value.

CF—— net cash flow in year t.

r——discount Rate.

According to the Black-Seholes option definition model, the value of fishery investment options is as follows:

$$C_i = S_0 N(d_1) - Xe^{-rT} N(d_2) \tag{12}$$

$$d_1 = \frac{\ln(\frac{S_0}{X}) + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \quad (13)$$

among them:

C_i——the value of fishery investment options under the i investment plan.

S_0——the net present value of fishery cash inflow after increasing investment.

N——cumulative normal distribution function.

X——fishery investment in the next stage.

r——indicates the risk-free interest rate.

T——the validity period of the option.

σ——the fluctuation of the underlying asset.

The total investment in fisheries is $ENPV = NPV + C_i$. According to the principle of investment decision-making, the greater the investment value, the better the investment plan.

If $ENPV \geq 0$, the fishery investment plan is feasible.

If $ENPV < 0$, the fishery investment plan is not feasible.

According to relevant data from the Scottish Fisheries Research Centre, and considering the economic strength of small fishing companies, we estimate that a small fishing company purchases a fishing boat worth 3 million yuan. The total cost of breeding and fishing is about 2 million yuan per year, and the annual labor expenditure is about 1 million yuan. The discount rate is calculated at 10%. We substitute the fishery investment option value of the three options into the model, and get the total investment value of which option is 105,600 yuan, 123,700 yuan and 162,200 yuan. The risk-free interest rates are 21%, 27% and 23% respectively. Asset volatility is 13%, 16% and 12%, respectively. According to estimates, in the fifth year of investment, $ENPV$ will reach RMB 562,100, RMB 8,452,400 and RMB 6,229,900, respectively.

In summary, $ENPV$ is the largest when choosing the second investment decision. Therefore, we recommend that small fisheries companies change their management model and move their companies to places close to these two types of fish.

3 Conclusion

In order to solve the future difficulties that small fisheries companies that use herring and mackerel as their main products may encounter in the future, a correct investment decision that be made under the migration of the two types of fish is very necessary. To predict the migration location of the two species of fish, we first predict the ocean surface temperature. On the basis of obtaining the sea surface temperature, through regression analysis and prediction model, the close degree of the correlation between the positions of the two fish schools, the sea surface temperature and the time is analyzed to determine the relationship between them three. Thereby the future migration position of the two fishes are be predicted. Due to the cost uncertainty and income uncertainty of small fishery companies, we use the real option value method to calculate the total investment value of different decision-making schemes. According to the analysis of the decision model, we conclude that small fishing companies should move to the vicinity of fish.

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