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Analysis of herring migration trends based on SST——a case study of Scotland

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ABSTRACT： Ocean temperature affects the quality of marine habitat. As global warming becomes more and more serious, seawater temperature is rising. This trend causes many fish migrating, thus affecting fisheries development in many areas. Now we analyze this phenomenon. Here we choose to use sea surface temperature (SST) instead of fish location information. Initially, we use ArcGIS trend analysis, GM (1,1) model and time series model to predict fish stock position .We acquired remote sensing image data from NASA, and then obtained SST images of the waters near Scotland through the processing of Envi and ArcGIS. Subsequently, we first use ArcGIS to analyze the change trajectory of the point, and then use the above two forecasting models to fit the location information that the fish may arrive.

1. Introduction

As the global warming trend becomes increasingly obvious, the ocean surface temperature is gradually rising globally [1]. Faced with the increase of sea temperature, many fishes will migrate to their suitable habitats. This phenomenon will have an impact on local fisheries in some extent, so we need to analyze the trend.

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2. Modeling to Solve

2. 1 Solution of problem 1

Because fish population migration is influenced by many factors, we ignore other effects and only to analyze the water temperature, we regard the change route of water temperature as the migration route of the fish.

First, we obtained SST[2]remote sensing data from NASA for nearly 20 years in the waters near Scotland and imported it into Envi[3] software for radiometric calibration and atmospheric calibration to leading-out[4].

Since the projection of remote sensing images is not equidistant, we set the top left of the original image as the origin of the coordinates and give a fishing ground estimate point on the Scottish coastline[5]. We choose to firstly analyze the law of year change causing P position change. As shown in Figure 1, we have mapped the point data in the two decades from 1999 to 2018 on May and derived its relative coordinates (X_{ij}, Y_{ij}).

We use Matlab to draw points according to its x, y coordinates, and observe its changing trend by linear fitting. We find that the annual $12^{\circ}C$ isotherm does have the trend of moving eastward and northward, but the trend is not particularly obvious in the short term.

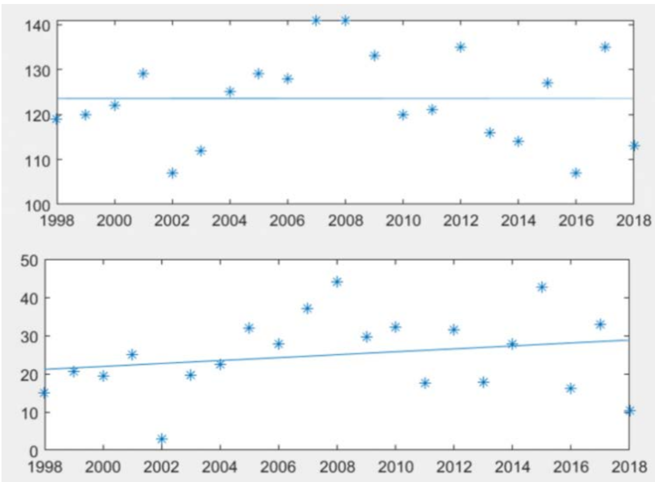

Figure 1: X and Y-coordinate plot of points

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2. 1. 1 Solve by ArcGIS

Since the above image data is not the data under the isometric projection map, we import the data into the isometric projection map for analysis. According to the point coordinates of the data, ArcGIS is used to analyze the moving trend of the center position in three dimensions.

Draw the three-dimensional trend diagram of point coordinate movement, as follow:

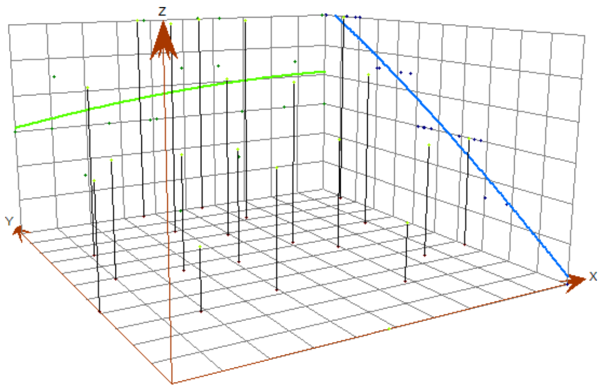

Figure 2: Through the ArcGIS three-dimensional trend analysis

According to the three-dimensional trend map drawn by ArcGIS, we use matlab for hier- archical division, and get Figure 3:

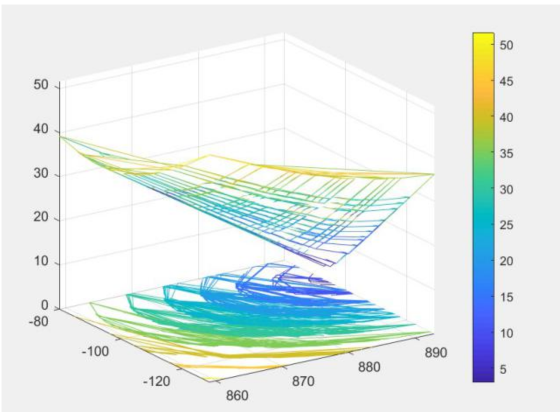

Figure 3: Matlab 3D data realized by ArcGIS 3D data

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According to the three-dimensional trend analysis, the center position of the shoal moves to the north obviously. We used this trend to plot the trend of fish movements over the next 50 years. Wecanseefromthetrendchartthatoverthenext50years, the shoals will gradually move toward the Faroe Islands and continue to move northward.

2.1.2 Solve by model

For fisheries, there is a certain harvest radius, and we process the data for 1999-2018 through relative distance, by equation:

$$D=\sqrt{(X_{ij}-X_P)^2+(Y_{ij}-Y_P)^2} \quad (1)$$

Therelativedistancefromthefishinggroundtoitscentralpositionisdescribedbytracing point, and the target is fitted by linear and least square methods.

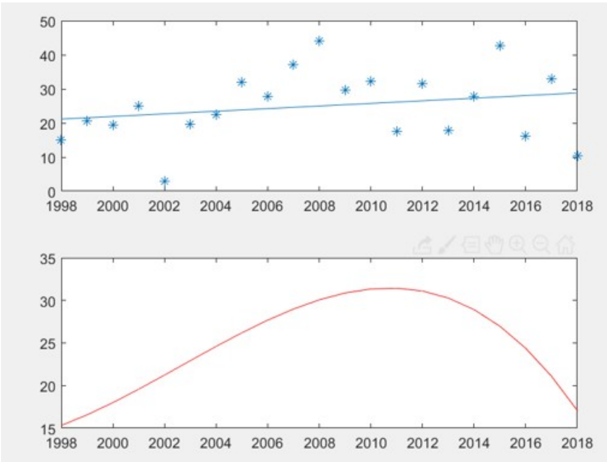

Figure 5: Fitting images from 1999 to 2018

The distance from the predicted fishing ground to the central position is beginning to show signs of diminishing. We then used the same approach to obtain information for each month of 2013-2018, and we estimated the relative distance of the fish from fishing estimated points over the next 50 years through the time series and grey (1,1) , respectively.

Time series model [6]

Let a certain periodic data be $X_{ij}(i=1,2,\cdots,n;m=1,2,\cdots,12)$,

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with a total of n years data, with 12 data per a year. Forecast for the next 12 months now.
In order to extract seasonal items, we calculate the i-year average

$$\overline{X} = \frac{\sum_{j=1}^{12} X_{ij}}{12} \quad (i = 1, 2, \cdots, n) \tag{2}$$

Zero-mean for each month date:

$$st_{ij} = X_{ij} - \overline{X}_i \quad (i = 1, 2, \cdots, n; m = 1, 2, \cdots, 12) \tag{3}$$

And the seasonal item is:

$$S_j = \frac{\sum_{i=1}^{n} st_{ij}}{n} \quad (j = 1, 2, \cdots, 12) \tag{4}$$

The S_j is seasonal item, and there t=12.Clearlysatisfied$S_1+S_2+\cdots+S_{12}=0$

Then we get post-seasonal data:

$$Y_{ij} = X_{ij} - S_j \quad (i = 1, 2, \cdots, n; j = 1, 2, \cdots, 12) \tag{5}$$

Straighten the data by row, assuming that:

$$Z = \vec{Y} = (Y_{1,1}, Y_{1,2}, \cdots, Y_{1,12}, Y_{2,1}, Y_{2,2}, \cdots, Y_{2,12}, \cdots, Y_{n,1}, Y_{n,2}, \cdots, Y_{n,12}) = (z_1, z_2, \cdots, z_{12n})$$

.

Usingpolynomialregressionfittingfordata$z_1, z_2, \cdots, z_{12n}$,suchasaprimaryorquadratic polynomial. If set regression out comes is

$$z_t = a + bt \quad (t = 1, 2, \cdots, 12 \times n) \tag{6}$$

The forecast for the next 12 months after the elimination of the season term is $\hat{z}_{12n+1}, \hat{z}_{12n+2}, \cdots, \hat{z}_{12n+12}$. That is $\hat{Y}_{n+1,1}, \hat{Y}_{n+1,2}, \cdots, \hat{Y}_{n+1,12}$.Then the forecast for the next 12 months in the raw data is

$$\hat{X}_{n+1,j} = \hat{Y}_{n+1,j} + S_j \quad (j = 1, 2, \cdots, 12) \tag{7}$$

According to this series of formulas, we draw the figure 6 through

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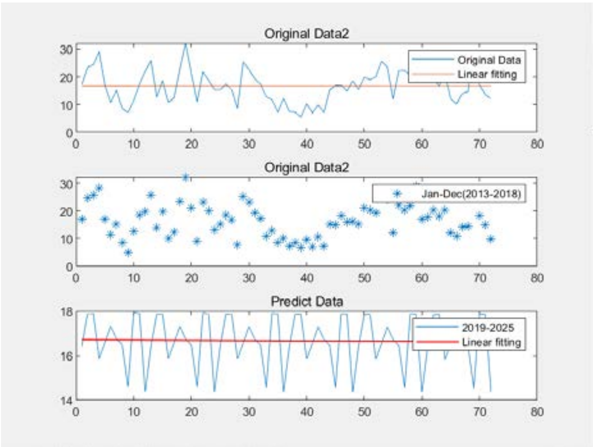
matlab: 

Figure 6: Time series prediction

From the figure 6, we can see that the distance between the center of the isotherm and the assumed fishery will be smaller and smaller without other factors.

GM (1,1) model [7]

The obtained gathering distance data D is converted into a known sequence $x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)$ do one summation AGO Generation of new sequences: Which $x^{(1)}(1) = x^{(0)}(1), x^{(1)}(2) = x^{(0)}(1) + x^{(0)}(2), \cdots, x^{(1)}(n) == x^{(1)}(n-1) + x^{(0)}(n)$

Generating mean sequence:

$$z^{(1)}(k) = \alpha x^{(1)}(k) + (1-\alpha) x^{(1)}(k-1) \quad (8)$$

Among them α = 0.5.

Establish a gray differential equation:

$$x^{(0)}(k) + az^{(1)}(k) = b \quad k = 2,3,\cdots,n \quad (9)$$

The corresponding whitening differential equation GM(1,1) is:

$$\frac{dx^{(1)}}{dt} + ax^{(1)}(t) = b \quad (10)$$

Let's transform equation (9) into:

$$-az^{(1)}(k) + b = x^{(0)}(k) \quad k = 2,3,\cdots,n \quad (11)$$

Among them a, b for the pending model parameters. That is:

$$X\beta = Y \quad (12)$$

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Among them $X=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \cdots & \cdots\\ -z^{(1)}(n) & 1\end{bmatrix},\beta=\begin{pmatrix}a\\ b\end{pmatrix},Y=\begin{pmatrix}x^{(0)}2\\ x^{(0)}3\\ \cdots\\ x^{(0)}n\end{pmatrix}$

Solve the equation (12) and the least squares solution is:

$$\hat{\beta}=(a,b)^T=(X^TX)^{-1}X^T.Y \tag{13}$$

The discrete solution of GM (1,1) model is obtained by solving the differential, equation(10):

$$\hat{x}^{(1)}(k)=[x^{(0)}(1)-\frac{b}{a}]e^{(-\alpha(k-1))}+\frac{b}{a}\quad k=2,3,\cdots,n \tag{14}$$

Restore to the original sequence, and the prediction model is:

$$\hat{x}^{(0)}(k)=\hat{x}^{(1)}(k)-\hat{x}^{(1)}(k-1)\quad k=2,3,4,\cdots,n \tag{15}$$

Substitute equation (14) into equation (15) to obtain:

$$\hat{x}^{(0)}(k)=\hat{x}^{(1)}(k)-\hat{x}^{(1)}(k-1)\quad k=2,3,4,\cdots,n \tag{16}$$

According to the above formula, we draw the figure (7) through matlab:

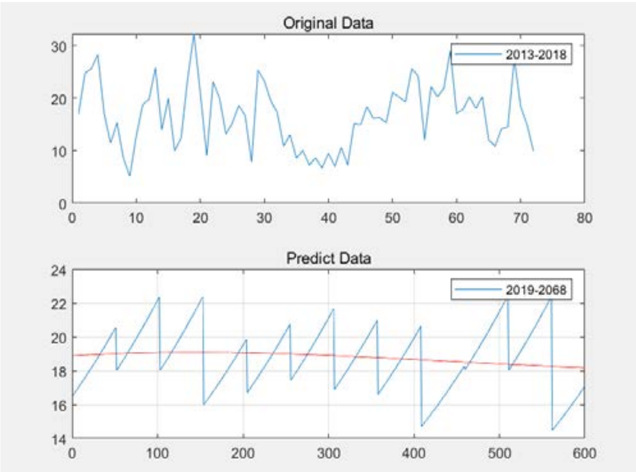

Figure 7: GM (1,1) prediction

A scan be seen from figure (7), both the original and forecast data are volatile. And forecast data are volatile at the same time, a downward trend overall.

By predicting the direction in which the center of the isotherm will move and by predicting the distance, we infer that in the next 50

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years the location of the shoals will move northeastward, slightly closer to the predicted fisheries.

3. Conclusion

This paper studies migration trends based on SST herring, which may have an impact on the local fishing industry, and also shows that global warming will have a huge impact on various industries.

Global warming will not only increase the frequency of natural disasters through sea level rise, but also bring harm to human body through the research report of Chenjuqing[8]. Research by the xinjiang agricultural reclamation science and technology [9] also shows that global warming will increase the incidence of infectious diseases. In a word, to control global warming is urgent!

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