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Using Mathematical Model to Analyze the Northward Migration of Marine Life

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ABSTRACT

This paper studies the migration of fish caused by the rise of sea water temperature caused by global warming. It is required to predict the migration sites of herring and mackerel in the next 50 years, as well as the best, worst and most likely time for small-scale fishing companies in the original area of Scotland to continue fishing, and to formulate reasonable business strategies for such companies, while taking into account the territorial waters of other countries. The grey prediction model and linear regression model are established. By querying the sea temperature in the geographic location range (,) from 2010 to 2018, we predict it in terms of the quarter as the time unit. Because the result of grey prediction model is not in accordance with the reality, the final data is obtained by linear regression model. According to the data analysis, the migration routes of fish are all northward, and the main direction is to migrate to the coast of Norway, but some of herring will move to the coast of Iceland later. The grey prediction algorithm and BP neural network algorithm used in this paper have been widely used in solving all kinds of practical problems in reality, so the conclusion of this paper is feasible and extensive.

Keywords: Move north; Grey prediction; Linear regression model; Ecological planning

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1. Introduction

Global ocean temperature will affect the quality of some Marine habitats. When the temperature change is too big to continue to grow up, these species began to look for other more suitable for the present and future life and reproductive success of habitat. United Nations Convention on the Law of the Sea [1]: According to the 1982 United Nations convention on the law of the definition, the definition of the territorial sea is along the baseline stretching up to 12 nautical miles Long-Wave Sea Surface Temperature: The sea surface temperature measured by MODIS and VIIRS infrared radiometers is commonly referred to as the skin temperature of the ocean. Small fishing boat: The fishing income is determined by the size of fishing boats, the distance from fishing point to port and many factors [2].

2. The Problem to be solved

2.1 Analysis of problem

Using historical data from the Wikipedia, we get the data of sea surface temperatures at different latitudes and longitude in previous year and determine initial conditions for our model. According to the description in the *PROGRESS IN OCEANOFRAOHY*, we get information about herring and mackerel (herring lives from 1 $^{\circ}C$ to 18 $^{\circ}C$ and mackerel lives from 11 $^{\circ}C$ to 14 $^{\circ}C$ and both species are found in shallow waters). In order to better understand the distribution of fish, we used ArcGIS to visualize its distribution, as shown in the figure below [3]:

Figure1: Fish Map

To solve the problem, we extend north based on the water off Scotland. As global warmingcauses sea temperatures to rise, it can be inferred that the general direction of movement of fish is northward. Thus, we're only looking at latitude 56 $^{\circ}N$ and 60 $^{\circ}N$. Since they live near the coast and Scotland is northeast of Norway and northwest of Iceland, we only look at longitude 360 $^{\circ}E$ and 2 $^{\circ}E$. Refer to the ocean temperature of the selected area above, use the gray prediction model, analyze whether the result is reasonable, and get the final result after improvement.

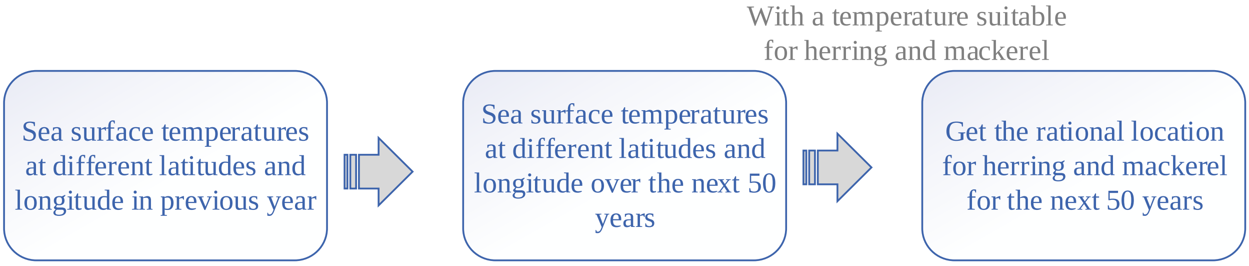

Figure 2: Modeling flow

2. 2 Solution of problem

This is a study of where fish will eventually migrate over the next 50 years due to rising sea temperatures caused by global warming. So, we're using past ocean temperatures to predict the next 50 years and determine the optimal location.

2.3 The establishment of model

2.3.1 Location based on Grey Forecasting Model

First, we check data for herring and mackerel survival area roughly range of temperature and the current existence [4].

Using JAVA has been designated area (from 56 $^{\circ}N$ to 60 $^{\circ}N$ and 360 $^{\circ}E$ and 2 $^{\circ}E$) from 2010 to 2017, water temperature, we pick out the scope of the analysis, on a quarterly as time series of research, get the final data.

Because we have normal ocean temperature data, so we use the existing data to reflect the data characteristics of the next 50 years. Using time series to construct the grey prediction model, the characteristics of the future at some point. Using data from 2010 to 2017 as sample data is used to calculate the model parameters, and then the numerical predict the next 50 years.

Categorizing data, using a_n^m said data (By n classification, by m years, will remember 2010 for 1 year, 2017 for 8 years).

According to the first data to establish original data column: Set $x^{(0)}$ for the sequence of n elements:

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \cdots, x^{(0)}(10)) = (a_1^1, a_1^2, a_1^3, \cdots, a_1^8)$$

Again for $x^{(0)}$ 1-AGO operation, we get $x^{(1)} = (a_1^1, a_1^2, a_1^3, \cdots, a_1^8)$ (1-AGO operation is to accumulate operation to generate the $x^{(0)}$ series).

The process of accumulating as shown below:

$$\begin{cases} x^{(1)}(1) = x^{(0)}(1) \\ x^{(1)}(2) = x^{(0)}(1) + x^{(0)}(2) \\ \ldots \\ x^{(1)}(10) = x^{(0)}(1) + \ldots + x^{(0)}(8) \end{cases}$$

Accumulation in the series to represent the accumulation and formulas, which expressed in $x^{(1)}(t)$ for the first few items data accumulation

$$x^{(1)}(t) = \sum_{k=1}^{t} x^{(0)}(k), (t = 1, 2, 3, \cdots, 8)$$

Move on to the GM (1, 1) model (GM (1, 1) first-order differential equation model of a variable):

Make $d=0.5$ and obtain the closely neighborhood value of $x^{(1)}$, then generate the sequence $z^{(1)}$:

$$z^{(1)}=(z^{1}(2),z^{1}(3),\cdots,z^{1}(8))$$

From this equation, we know that: $z^{(1)}(k)=d(x^{(1)}(k)+(1-d)x^{(1)}(k-1),k=2,3,\cdots,8$

Establish a first-order linear differential equation with respect to $x^{(1)}(t)$, what's more, 'a' and 'b' are constant. 'a' is grey number of developments [5], 'b' is ash dosage. Remember a and b of the matrix of the $(a,b)^{T}$.Requires only the parameters of a and b, $x^{(1)}(t)$ can be solved, and the future forecast of $x^{(0)}$.

Build a data matrix Y and vector data B, we get:

$$Y=\left[x^{(0)}(2);x^{(0)}(3);x^{(0)}(4);\cdots;x^{(0)}(8)\right]$$

$$B=\left[-z^{(1)}(2),1;-z^{(1)}(3),1;-z^{(1)}(4),1;\cdots;-z^{(1)}(8),1\right]$$

Getting the value of u:

$$u=(a,b)^{T}=\left(B^{T}*B\right)^{-1}*B^{T}*Y$$

Therefore, the white differential equation corresponding to the grey equation can be established:

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

Use data to merge and make the use of MATLAB.

In order to make the process more concise, we draw the flow chart:

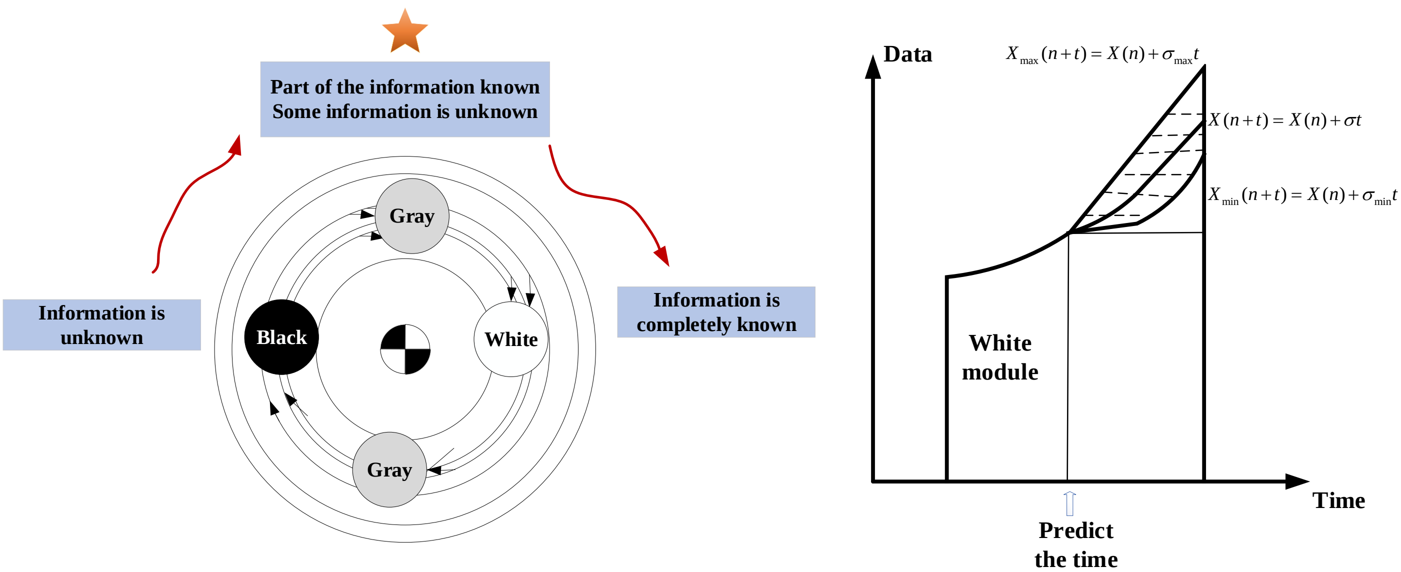

Figure3: Modeling flow

3. Results analysis

Using dichotomy fitting to get the prediction results, and the analysis is more in line with the reality, so the analysis can get two kinds of fish migration routes and the final location. Using MATLAB to get the position of two kinds of fish in the next 50 years:

Table1：Fitting temperature

	56N		58N		60N		62N		64N		66N	
	350E	2E	350E	2E	350E	2E	350E	2E	350E	2E	350E	2E
2010.0	14.4	15.0	13.6	14.4	12.6	13.8	11.3	13.1	9.9	12.4	8.5	11.7
2011.0	13.6	14.5	13.0	14.0	12.1	13.6	11.0	12.9	9.7	12.2	8.5	11.4
2012.0	14.2	14.4	13.4	13.7	12.3	13.1	11.0	12.4	9.5	11.6	8.1	10.9
2013.0	14.2	15.1	13.3	14.4	12.3	13.7	11.1	12.9	9.5	12.0	8.0	11.2
2014.0	14.8	16.2	14.1	15.5	13.2	14.9	12.1	14.1	10.8	13.3	9.6	12.6
2015.0	13.3	14.7	12.7	14.1	11.9	13.4	10.8	12.7	9.6	12.1	8.4	11.5
2016.0	14.3	15.4	13.5	14.7	12.5	14.0	11.3	13.2	10.0	12.5	9.0	11.8
2017.0	14.4	15.4	13.7	15.0	12.8	14.4	11.8	13.7	10.5	13.0	9.4	12.3
2018.0	14.2	15.6	13.5	15.0	12.6	14.3	11.6	13.6	10.4	12.9	9.4	12.2
	…	…	…	…	…	…	…	…	…	…	…	…
2039.0	14.5	18.3	14.0	17.9	13.5	16.8	13.1	15.8	12.7	15.3	12.9	14.9
2040.0	14.5	18.5	14.0	18.0	13.6	16.9	13.1	15.9	12.8	15.4	13.1	15.0
2044.0	14.6	19.0	14.1	18.6	13.8	17.4	13.4	16.3	13.3	16.0	14.0	15.6
2045.0	14.6	19.2	14.1	18.8	13.8	17.5	13.5	16.5	13.4	16.1	14.2	15.7
2048.0	14.6	19.6	14.2	19.2	14.0	17.9	13.7	16.8	13.8	16.5	14.8	16.2
2049.0	14.6	19.8	14.2	19.4	14.0	18.1	13.8	16.9	13.9	16.6	15.1	16.3
2050.0	14.7	19.9	14.2	19.6	14.0	18.2	13.9	17.1	14.0	16.8	15.3	16.5
2051.0	14.7	20.1	14.3	19.7	14.1	18.3	14.0	17.2	14.2	16.9	15.6	16.6

Table 1 is the temperature suitable for mackerel in the third quarter of the next 50 years，From the above table, we can know the migration range of fish in the future.

Herring's migration route is from the coast of Scotland to the north. There will be two directions to Norway and Iceland in the early stage of the third and fourth quarters, but in the later stage, Iceland will be the main migration route, while in the first and second quarters, the predicted results in the next 50 years will not be too large, and it will migrate to the current region; however, the living conditions of mackerel are relatively fragile, so the migration time is earlier than herring's The route also migrates to the north, but with Norway as the main direction, the data shows that mackerel will not migrate to the same year in the future.

4. Model optimization

When considering the migration route of fish, we should add the influence of natural enemies and wind field. Because natural enemies will change the original migration location of fish, and along the wind field will be conducive to migration of fish, so natural enemies and wind field should be considered.

5. Conclusions and Outlooks

The gray prediction model needs less data, more accurate prediction and higher accuracy. The sample distribution does not need regularity, the calculation is simple and the test is convenient. The grey prediction model is suitable for medium and long-term prediction. In addition to the impact of sea surface temperature on fish migration, there are many other factors, the most typical of which is the chemical substances in the sea water. Because of the different ability of fish to regulate osmotic pressure, the distribution of fish is different. At the same time, the pH value and dissolved oxygen of sea water also affect the migration of fish. Based on the above two kinds, we can analyze the favorite sea areas of different fish, and then establish the appropriate density model of fish in the sea area, so as to select the best place. Based on this model, we can predict the likely location of various fish species in the future.

References

1. www.fao.org/fishery/area/search
2. Iversen, S.A., Kirkegaard, E., Westga˚rd, T., 1987.Mackerel egg production and spawning stock sze in the North Sea 1986.ICESC. M.1987/H:8.
3. Reid, D.G., Eltink, A., Kelly, C.J., 2003a.Inferences on the changes in pattern in the prespawning migration of the western mackerel (Scomber scombrus) from commercial vessel data. ICESCM2003/Q:19.
4. Nielsen, R., Landgren, B., Stæhr, K.J., 2001.Distribution, density and abundance of the western Baltic herring (Clupea harengus) in the Sound (ICESSubdivision23) in relation to hydrographical features.Fish.Res.(Amsterdam)50,235–258.
5. http://www.fao.org/publications