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Fishing Model based on Seawater Temperature Prediction

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Abstract

Seventy percent of the Earth's surface area is covered by water. As the pace of global warming accelerates, some species in the ocean have to make compromises, and we have to be forced to make compromises. Therefore, this article predicts the interaction between us and marine populations. The impact will become very meaningful. First, I have established research indicators to study the effects of changes in ocean water temperature on the habitat of Scottish herring and mackerel. In the light of seasonal time series based on world ocean temperature changes over the past 20 years. I built a seasonal time series ASIMA model of seawater temperature, based on which we made water temperature forecasts around the North Atlantic for the next 50 years, and identified the most likely locations for Scottish herring and mackerel in the next 50 years.Secondly, using prediction data for bilinear interpolation to determine the best or worst impact of Scottish herring and mackerel habitats on North Atlantic small fishing companies, and the time that the impact is most likely to pass.Thirdly, from the above directions, we have established a 0-1 integer programming model that considers the business strategy of small fishing companies to increase revenue through site selection, and recommendations for the strategy when it is used to relocate some fisheries to another country.What's more, in the pros and cons test of the model, the time series model is applied in this case with a high degree of fit, under the same conditions, the fitting degree is much higher than the Grey Model. The comparison between the two shows that the time series model is more suitable in this case. Then analyze the advantages and disadvantages of 0-1 integer planning in the location problem.

Keywords

ARIMA Model; Bilinear Interpolation; 0-1 Integer Programming Model.

1. Introduction

Because people burn fossil fuels, such as oil and coal, or cut down forests and burn them, they produce large amounts of greenhouse gases, and large amounts of greenhouse gases accumulate, resulting in an imbalance in the energy absorbed and emitted by the Earth's gas system, energy accumulates continuously in the Earth's atmosphere system, leading to rising temperatures and global warming. Global Ocean temperatures are rising at an alarming rate as the world warms, with the past five years the warmest on record, according to research, and the trend continues.

Marine temperature directly affects the quality of life of marine species. When the temperature changes too much, marine organisms can not continue to survive and reproduce, these species migrate in search of a habitat that is more suitable for them to live and reproduce. One example is the lobster population in Maine, which is slowly migrating north to Canada, where lower ocean temperatures provide a more suitable habitat. Such geographic migration can seriously disrupt the livelihoods of companies that depend on the stability of marine life.

The optimum temperature for a shoal of fish is below 10 ℃, as Global Ocean temperatures rise, Scottish herring and Mackerel may migrate from their habitats near Scotland, changing the distribution of their populations, making them economically impractical for fishing companies. Therefore, we need to develop a mathematical model to determine the most likely habitat for these two fish species over the next 50 years, and to generalize to other organisms.

2. Model for predicting fish habitat by water temperature

2.1 Problem hypothesis

1) Considering only the effect of changes in water temperature on fish shoals.

2) The fish studied did not have a genetic change related to adaptation to temperature.

3) The cost of going to sea by fishing vessels was only related to distance and whether or not it was transnational, regardless of the damage caused by natural disasters.

4) The habits and habitats of the two species are largely the same.

5) The position of the small-scale Fishery Company is only found in Port.

6) The data are accurate and reliable.

2.2 Problem analysis

In order to predict the likely habitat of fish stocks in the coming decades, and the state of operation of fishing companies, the following steps are required:

Firstly, water quality, water temperature, water depth and so on are the factors that affect the fish habitat environment. Analysis using monthly ocean temperature data [1] obtained worldwide since 2000.

Secondly,I judge the characteristics of the data, choosing the prediction methods, the data prediction methods mainly include regression analysis prediction method, time series prediction method, grey system prediction method, neural network prediction method, etc., in view of the fact that the data obtained in this question is time series and seasonal, the time series model [2] is the mostsuitable, combining the existing data to forecast the following 50 years data of various indicators.

Thirdly,Based on the established models, the range of possible habitats of fish stocks is analyzed, and the duration of reaching the threshold level is predicted by forecasting models, and the relationship between the profit and loss of small fishing companies and the position of fish stocks is established, to make recommendations to small fishing companies.

Finally, fish stocks are not affected when they move across national borders, but companies can incur costs that vary from country to country and culture to culture.

The migration of fish stocks is a major event for fishers and is bound to affect their income and happiness index,making more accurate predictions for the future and providing them with more economical alternatives.

2.3 Model establishment and solution

The MODEL was developed to describe the trend in ocean temperatures near Scotland and to predict future ocean temperatures. The data our team found is shown in Table 1.

In order to verify the authenticity we said, a map of the world's ocean water temperature is released here, Fig. 1.

I selected the sea water temperature data from 53°-58° N to 1°-6° W to make the Fig. 2, and judged that it was consistent with the seasonal sequence. [6]

Because the data has a seasonal tendency, the following differential operations are performed on the data: X_t represents the sea temperature in the t-th month, 1-month sampling interval. Obviously, X_t will contain 12 months of cyclical changes, May-November is the peak temperature of water. There was a trough from January to March. Normally, the sequence of the period s can be subjected to a difference operation first, that is,

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$$w_t = \nabla_s X_t = (1 - B^s) X_t \quad (1)$$

$$\nabla_s^d = (1 - B^s)^d X_t \quad (2)$$

Here s=12, d=1 is determined by the calculation, which yields Fig. 3.

Table 1. Partial Ocean temperature data

Longtitude &Latitude / Temperature / Time	53°N 1°W	54°N 2°W	55°N 3°W	56°N 4°W	57°N 5°W	58°N 6°W
200001	7.067918301	6.711663246	6.952794075	6.963887215	6.944746971	7.316978931
200109	15.30227184	15.71600819	14.53201103	14.30317593	14.53126144	14.70110607
200305	10.84414482	10.67494011	10.44516945	10.00675297	9.587741852	9.15293026
200501	6.943918228	6.700663567	7.118793964	7.228887081	6.699747086	6.893979073
200609	16.38027191	15.82200813	15.51301098	15.56917572	15.6052618	15.64210606
200805	11.46814537	11.29394054	11.0351696	11.1417532	11.17074203	10.63193035
201001	5.746918201	5.729663372	5.61379385	5.530887127	5.817747116	6.636979103
201109	14.77527237	14.38600731	13.28401089	13.47417545	13.83626175	13.80310535
201305	9.031145096	9.321940422	9.111169815	8.552753448	8.184741974	7.846930027
201501	7.538918495	7.25766325	7.365794182	7.342887402	6.908746719	6.954978943
201609	16.0352726	15.81600761	15.26301098	14.66317558	14.41726112	14.38510609
201801	7.027918339	6.741663456	6.959794044	7.02288723	6.790746689	6.921978951
201909	15.6632719	15.97600746	15.46301079	14.92717552	14.43226147	14.54910564
200109	15.30227184	15.71600819	14.53201103	14.30317593	14.53126144	14.70110607
200305	10.84414482	10.67494011	10.44516945	10.00675297	9.587741852	9.15293026
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201801	7.027918339	6.741663456	6.959794044	7.02288723	6.790746689	6.921978951
201909	15.6632719	15.97600746	15.46301079	14.92717552	14.43226147	14.54910564

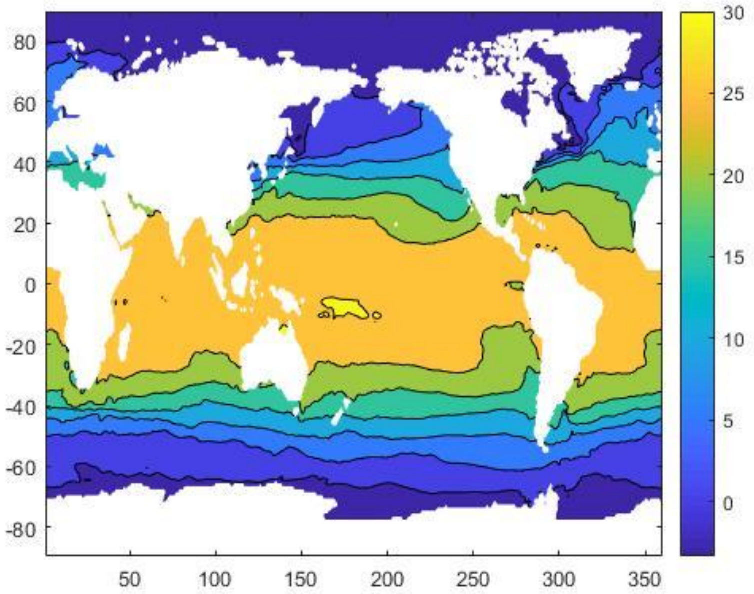

Fig. 1 The world's ocean water temperature

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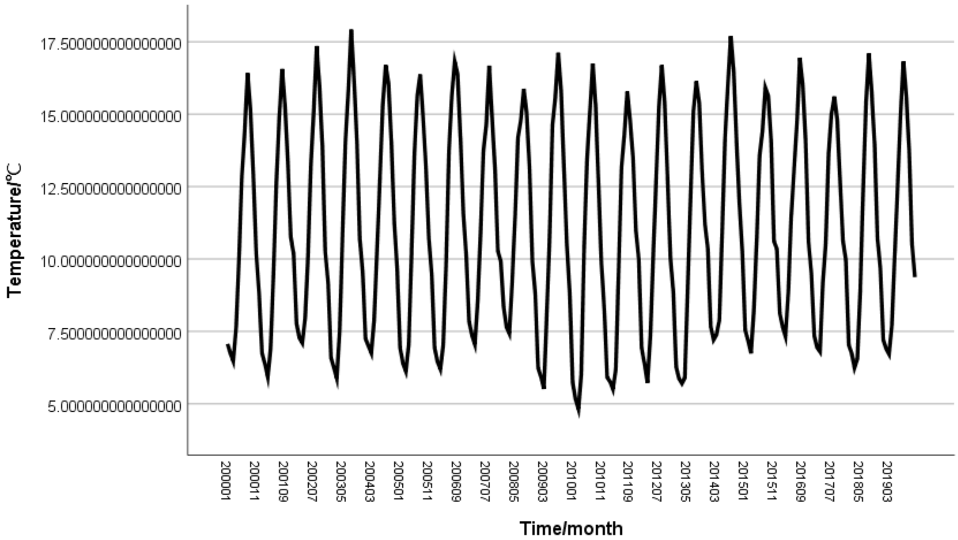

Fig. 2 The world's ocean water temperature

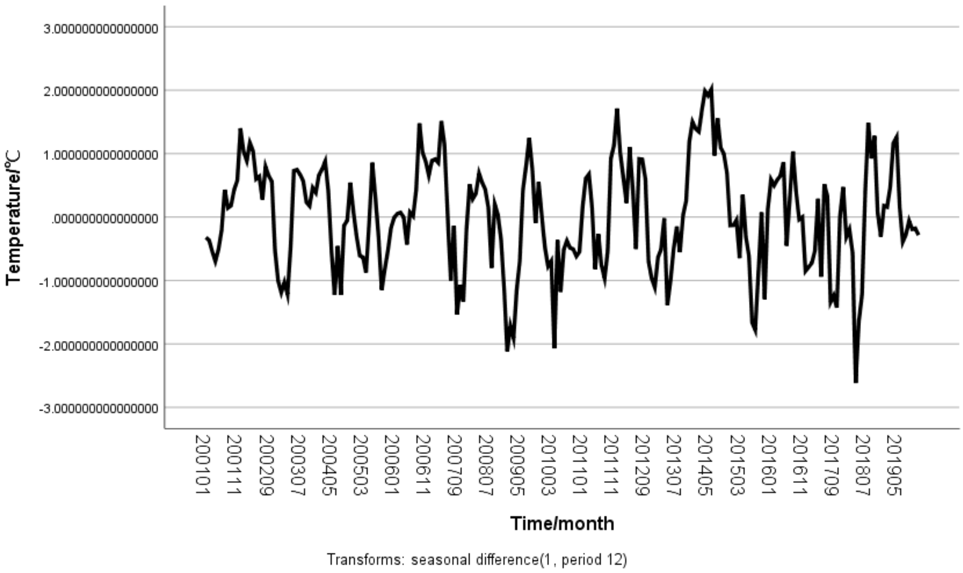

Fig. 3 Stationary sequence after difference operation

The model is ranked by AIC CRITERION:

$$\min \text{AIC} = n \ln \hat{\sigma}_\varepsilon^2 + 2(p+q+1) \tag{3}$$

Where: n is the sample size;the estimate of $\hat{\sigma}_\varepsilon^2$ as σ_ε^2 is related to p and q. If the upper form reaches the minimum when p=$\hat{p}$, q=$\hat{q}$, then the sequence is ARMA($\hat{p}, \hat{q}$). Calculated p=1, q=1.[2]

The parameter is estimated as

$$\hat{\varphi}_1 = 0.246$$
$$\hat{\theta}_1 = 0.993$$

The MODEL is

$$(1 - 0.246B)(1 - B)X_t = (1 + 0.993B)\varepsilon_t$$

Based on the above model, we can predict the results of the water temperature of the studied sea area in the next 50 years. Here, we use the water temperature data from 2000 to 2019 to predict the water temperature in the next 50 years, the predicted results of partial latitude and longitude are given at random intervals of 30 or 50 months. From the results of the model, we can see that the fish population

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is nearly far from the analysis area from May to October. The rest of the month, the fish habitat generally moves to 55°-58 °N, as shown in Fig. 4, until the beginning of 56°-58°N of the 2051, not Suitable for this school of fish, see Fig. 5. [3]

Using Matlab to solve the existing forecast data Fig. 6 is the best case in 2030, Fig. 7 is the worst case in 2052.

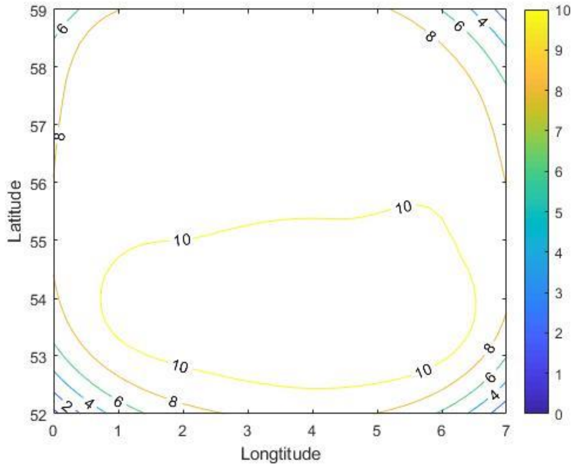

Fig. 4 November to April Isotherm Graph

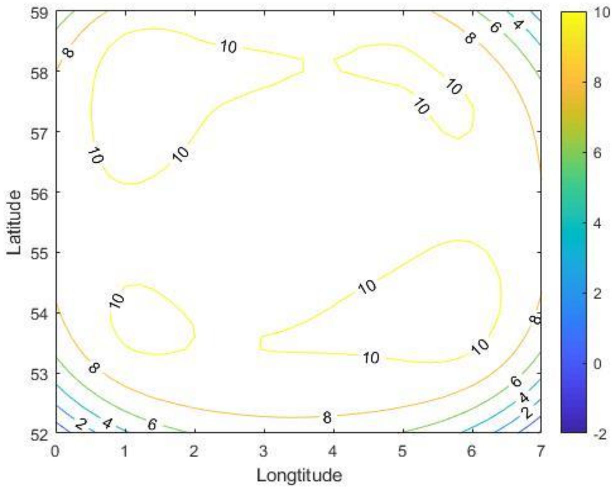

Fig. 5 May to October Isotherm Graph

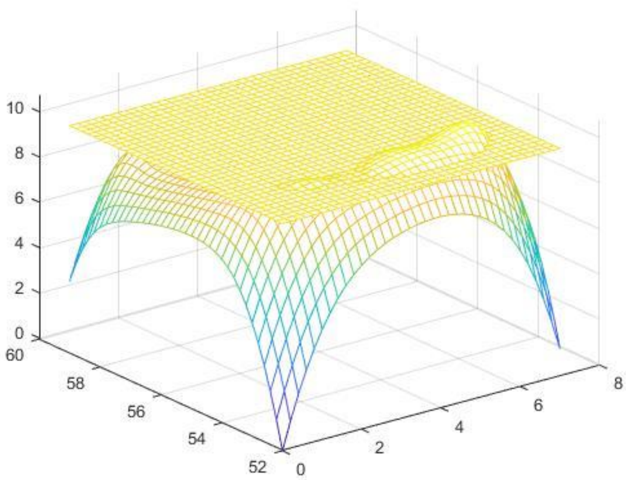

Fig. 6 3D illustration of the best conditions for habitats

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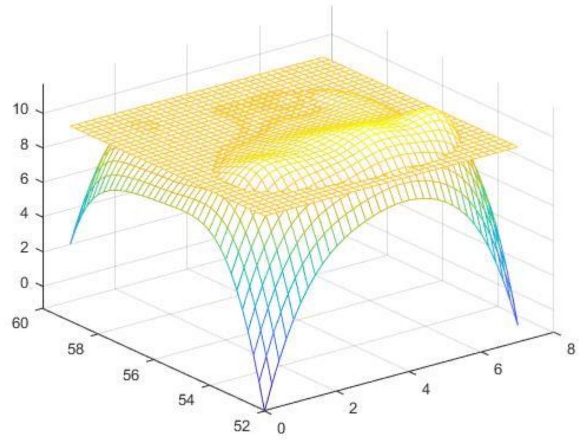

Fig. 7 3D illustration of the worst conditions for habitats

Based on the image, the ISOTHERMS were plotted, and the best-case habitats were found to be the 10 °C outer portion of Fig. 8 and the worst-case habitats to be the 10 °C outer portion of Fig. 9. [4]

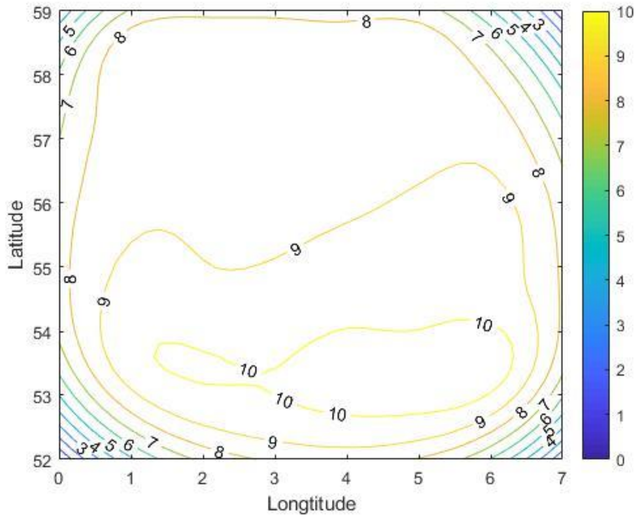

Fig. 8 Best-case isotherms

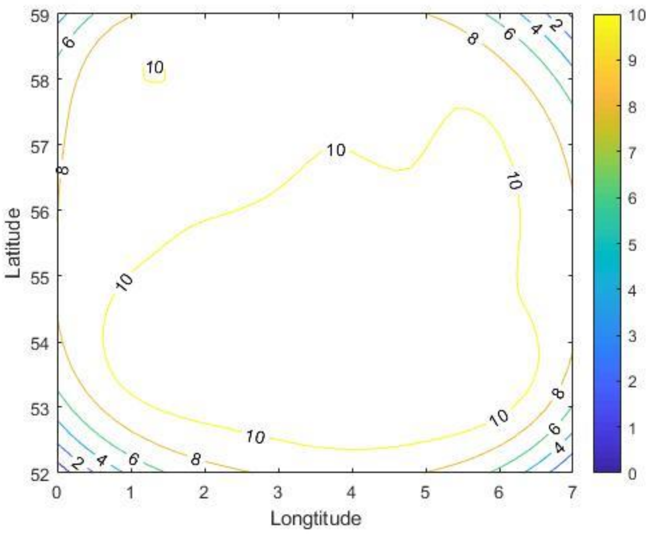

Fig. 9 Worst-case isotherms

Simulation of 8 fisheries $A_1, A_2, \cdots, A_8$, There are six potential fisheries sites $B_1, B_2, \cdots, B_6$, The fisheries they can cover are shown in Table 2.

Conditions of Coverage: Not Exceeding the maximum sea voyage D_{max} of a small fishing vessel

Table 2. Fisheries Company address selection simulation data

Address of fishing company	B_1	B_2	B_3	B_4	B_5	B_6
Covered fishing ground	A_1, A_5, A_7	A_1, A_2, A_5, A_8	A_1, A_3, A_5	A_2, A_4, A_8	A_3, A_6	A_4, A_6, A_8

This model is only for simulation. It should be determined according to the actual port location and fish habitat. [5]

$$x_i = \begin{cases} 1, & Site\ at\ B_i \\ 0, & no\ Site\ at\ B_i \end{cases}$$

Since fishery A1 can cover alternative address B1, B2, B3, there are constraints

$$x_1 + x_2 + x_3 \geq 1$$

Similarly, other constraints can be written to establish the following 0-1 integer programming model

$$min \sum_{i=1}^{6} x_i$$

$$s.t. = \begin{cases} x_1 + x_2 + x_3 \geq 1 \\ x_2 + x_4 \geq 1 \\ x_3 + x_5 \geq 1 \\ x_4 + x_6 \geq 1 \\ x_5 + x_6 \geq 1 \\ x_1 \geq 1 \\ x_2 + x_4 + x_6 \geq 1 \end{cases}$$

Using Lingo software, the address of the fishing company is located at B1, B4, B5.

3. Conclusion

In the time series model for Predicting Fish Habitat, I investigated water temperatures in parts of the North Atlantic. In fact, if we were to use global ocean temperature data in our data processing, I might be able to get the global ocean habitat of the Scottish herring and the Mackerel.

The model combines the related knowledge, satisfies the general mathematical principle and the natural law, the water temperature prediction fish habitat time series model can be used to predict the precipitation problem, the temperature problem, the electricity consumption problem and so on, BILINEAR interpolation's 2D interpolation model can be used to map the seafloor, mark dangerous areas, etc.. The 0-1 integer programming model for the location of fishing companies can be used to select factories, schools, transportation options, etc.

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