Problem Chosen	2022 MCM/ICM Summary Sheet	Team Control Number
A		XJ162

test

Summary

Keywords: 123456

Contents

1 Introduction

1.1 Problem Restatement

Finless porpoise is the only freshwater mammal in the Yangtze River at present, which is distributed in the middle and lower reaches of the Yangtze River, Dongting Lake and Poyang Lake, and its population has decreased dramatically in the past 20 years. According to the statistics, the number of finless porpoises in the Yangtze River was more than 2,700 in 1991. However, in the year of 2006, there were fewer than 1,800 finless porpoises surviving in the area. In 2011, there were probably just over 1,000 of them, and in 2018 there were about 1,012.

In fact, since the 1980s, the ecologists along with the government had explored and developed three conservation strategies: in situ conservation, ex situ conservation and artificial breeding. Among them, ex situ protection, that is, selecting some waters with similar ecological environment to the Yangtze River to establish ex situ protection, is the most direct and effective measure to protect the Yangtze finless porpoise.

China has set up five ex-situ protected sites until now, in which more than 150 Yangtze finless porpoises are conserved. On September 18, 2021, CCTV reported that the population of the Yangtze finless porpoise is growing steadily. The population decline of the Yangtze finless porpoise has been curbed, but its critically endangered status remains unchanged.

Based on what has been discussed above, please address the following problems:

1 Establish a mathematical model to predict the population number of finless porpoises in five ex situ protected areas after 20 years, and explain how the sex ratio of 150 finless porpoises in ex situ protected areas affects the population development of finless porpoises.

2 Will the Yangtze finless porpoise become functionally extinct without ex situ conservation strategies?

3 Based on your analysis, please submit no more than 2 pages of recommendations for the protection of finless porpoises to the relevant authorities.

1.2 Overview of Our Work

2 Assumptions and Justifications

3 Notations

4 Model I:

Considering tremendous cost on massive finless porpoise population census, merely six years of data was collected during the three decades since 1992. (Zhigang (n.d.)) Thus, we've applied **Lagrange interpolation** to obtain other years' data. ((Xianfeng, 1999))

Table 3.1: Notation Descriptions

Symbol	Definition
$\mathbf{A}$	A set of artists given in dataset
$\mathbf{G}$	A set of genres provided in dataset
f_i	The total number of followers of artist i, $i \in \mathbf{A}$
g_{ij}	Genre tag between artist i and his or her follower j, $i, j \in \mathbf{A}$
DAS_i	Artist i's decade of active start, accurate to 10 years
r_{ij}	Respective Influence of influencer i over follower j, $i, j \in \mathbf{A}$
w_i	Artist i's weight of normalized indexes
TI_i	Artist i's Total Influence
wf_j	The parameter of follower j' influence, $j \in \mathbf{A}$
wt_i	The weight of artist i's Total Influence, $i, j \in \mathbf{A}$
cg_{ik}	Artist i's Contemporary Influence in certain genre, $i \in \mathbf{A}, k \in \mathbf{G}$
c_i	Artist i's Contemporary Influence, $i \in \mathbf{A}$
S_{ij}	Similarity between artists i and j

4.1 Lagrange Interpolation

Given n distinct real values $x_1, x_2, \cdots, x_n$and n real values $y_1, y_2, \cdots, y_n$ (not necessarily distinct), there is a unique polynomial P with real coefficients satisfying $P(x_i) = y_i$ for $i \in \{1, 2, \cdots, n\}$, such that deg($P$)<n.

The polynomial $P(x)$ is defined as follows:

$$P(x) = \sum_{k=1}^{n} y_k p_k(x), \quad p_k(x) = \frac{(x - x_1)\cdots(x - x_{k-1})(x - x_{k+1})\cdots(x - x_n)}{(x_k - x_1)\cdots(x_k - x_{k-1})(x_k - x_{k+1})\cdots(x_k - x_n)}$$

According to Lagrange interpolation, the number of finless porpoise population during past three decades are listed below.

5 Sensitivity Test

6 Evaluation of Model

7 Conclusions

Table 4.1: Estimated size of population on year basis from 1992 to 2022

Year	Number	Year	Number	Year	Number
1992	5	2002	20	2012	45.7364
1993	10.4864	2003	21.2919	2013	49.2555
1994	13.9987	2004	22.9647	2014	52.9737
1995	16.0839	2005	25	2015	57
1996	17.2014	2006	27.3612	2016	61.4941
1997	17.7296	2007	30	2017	66.6734
1998	17.9732	2008	32.8636	2018	72.82
1999	18.1701	2009	35.9015	2019	80.2876
2000	18.4981	2010	39.0724	2020	89.5084
2001	19.0819	2011	42.3514	2021	101

REPORT

To: ICM society

From: ICM Team 2104997

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References

Xianfeng, Z. (1999). Population viability analysis for the yangtze finless porpoise. *Bulletin of the Chinese Academy of Sciences:English Edition*, *27*(1), 3473-3484.

Zhigang, L. (n.d.). *The changes of micro-ecological of diseased yangtze finless and research on its protection under ex-situ* (Unpublished doctoral dissertation). Huazhong Agricultural University.

Appendices

Input matlab source:

```
clc;
clear;
x = [1992, 2002, 2005, 2007, 2015, 2021]    % Year
y = [5, 20, 25, 30, 57, 101]    % Number of Yangtze Finless Porpoises
xi = 1992:1:2022    % Prediction
yi = lagrange(x, y, xi)     % Lagrange Interpolation
plot(x, y, 'o', xi, yi, 'k')
title('Lagrange Interpolation Conservation 1')
xlabel('Year')
ylabel('Number of Yangtze Finless Porpoises')
```

```
function yy=lagrange(x,y,xx)    % Lagrange Function
m = length(x);
n = length(y);
if m~= n, error('Length of vector x and y should be the same');
end
s = 0;
for i = 1:n
    t = ones(1,length(xx));
    for j = 1:n
        if j~=i,
            t = t.*(xx - x(j))/(x(i) - x(j))    %Data (x, y) at interpolation point xx
        end
    end
    s = s + t * y(i)
end
yy = s
```

```
clc;
clear;
data = textread('conservation_1.txt');
data=nonzeros(data');     % Remove the zero elements in the order of the original data
r11=autocorr(data);        % Calculate the self correlation coefficient
r12=parcorr(data);     % Calculate partial correlation coefficient
figure
subplot(211),autocorr(data);
subplot(212),parcorr(data);    % The autocorrelation and partial autocorrelation of the ori
diff=diff(data);     % R11 is positive, not controlled by a negative exponential, so calcul
r21=autocorr(diff);        % Calculate the self correlation coefficient
r22=parcorr(diff);         % Calculate the partial correlation coefficient
adf=adftest(diff);     % If adf == 1, stable time sequence
figure
subplot(211),autocorr(diff);
subplot(212),parcorr(diff);       % Plot on the same figure, stable time sequence
n=length(diff);        % Caculate the differencial data
k=0;
  for i = 0:3
    for j = 0:3
```

```
        if i == 0 & j == 0
            continue
        elseif i == 0
            ToEstMd = arima('MALags', 1:j, 'Constant', 0);
        elseif j == 0
            ToEstMd = arima('ARLags', 1:i, 'Constant', 0);
        else
            ToEstMd = arima('ARLags', 1:i, 'MALags', 1:j, 'Constant', 0);    % Model struct
        end
        k = k + 1;
        R(k) = i;
        M(k) = j;
        [EstMd,EstParamCov,LogL,info] = estimate(ToEstMd,diff);   % Fitness, and estimate r
        numParams = sum(any(EstParamCov));
        [aic(k), bic(k)] = aicbic(LogL,numParams,n);
    end
end
fprintf('R, M, AIC, BIC value: \n%f');
check  = [R',M',aic',bic'];
res=infer(EstMd,diff);       % Verification
figure
subplot(2,2,1)
plot(res./sqrt(EstMd.Variance))     % Standardlized residual
title('Standardized Residuals')
subplot(2,2,2),qqplot(res)      % Fit the hypothesis of normality
subplot(2,2,3),autocorr(res)
subplot(2,2,4),parcorr(res)


% The autocorrelation coefficient rapidly decreases to 0 after 1 order lag,
% and the partial correlation coefficient is the same as the self correlation coefficient,
% so p = 1, q = 1
p=input('p = ');
q=input('q = ');
ToEstMd=arima('ARLags', 1:p, 'MALags', 1:q, 'Constant', 0);
 [EstMd, EstParamCov, LogL, info] = estimate(ToEstMd, diff);
 dx_forest = forecast(EstMd, 20, 'Y0', diff);       % 20 years prediction
 x_forest = data(end)+cumsum(dx_forest)
figure
h4 = plot(data, 'b');
hold on
h5 = plot(length(data)+1: length(data)+20, x_forest, 'r', 'LineWidth', 2);
title('ARIMA Sequence Prediction of Conservation 1')
xlabel('Year(since 1992)')
ylabel('Number of Yangtze Finless Porpoises')
hold off
```