INVESTIGATION OF CYCLIC CHANGES OF ZOOPLANKTON COUNTS AND SOME ENVIRONMENTAL FACTORS USING FOURIER ANALYSIS IN THE EASTERN HARBOR OF ALEXANDRIA EGYPT

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Abstract

Time series data of monthly counts of zooplankton, groups and species, and some environmental factors (water temperature, salinity and chlorophyll) were collected, in the Eastern harbor of Alexandria Egypt, in the period from October 1999 to November 2003. The biological investigation of these data has been dealt with in another publication [1]. In this paper 27 time series, each of length 36 months, for 3 environmental factors, 5 zooplankton groups and 19 zooplankton species, are analyzed using the Fourier analysis to find out the amplitudes and phase angles at the different cycles with periods between 2 and 36 months. The results show the periods of the relevant cycles affecting the movement of the time-series for each of the used variables including the groups, the species and the environmental factors, detected by the peaks of the periodogram (Frequency - amplitude chart).

Keywords : Time Series, Zooplankton.

Introduction

The study area is the Eastern harbor of Alexandria that lies at (31.2-31.214° N, 29.880 - 29.908° E). It is a semi-circular basin bounded at the open sea side by an artificial break water to protect the inner part of the harbor from the direct wave action especially in winter time. There are two outlets at the sea, eastern and western outlets. The depths lies between 1 and 9 meters with an average 5 meters and the largest depths are near the outlets. This area is important as a fishing harbor as well as a tourist site.

Data and methods of analysis

Time series analysis was applied on biological data [2]. The Fourier analysis is one of the important tools used in the investigation of the of any time series. It aims to fit the equally spaced time series by the summation of sine and cosine functions so that the variable value can be estimated. The main arguments in the equation are the amplitudes and phase angles relative to time series starting.

Tab. 1. Harmonic analysis peaks frequencies for zooplankton groups and environmental factors in the eastern harbor (1999-2003) indicated by sign (x).

VARIABLE	NO.
salinity	1
chlorophyll	2
temp	3
totalzoo	4
Ciiripede lar.	5
Polychaetes	6
Copepods	7
Rotifers	8
Titinnids	9

Period (month)	freq(cycles/36 month)	VARIABLE 1	2	3	4	5	6	7	8	9
36	1	X			X			X	X	X
18	2	X					X			
12	3		X	X		X		X	X	
9	4	X			X	X				X
7.2	5						X			
6	6		X				X	X		
5.143	7					X				X
4.5	8	X			X		X			
4	9									X
3.6	10							X		
3.273	11				X	X	X			X
3	12		X							
2.769	13				X	X				
2.571	14								X	
2.4	15	X	X			X				
2.25	16				X		X			
2.118	17									

The spectra represented as the relation between amplitude as y- axis and frequency as x- axis and the important peaks are corresponding to the main controlling cycles in the time series. The phase angles of the different variables enable to determine the time delay at a given frequency or given period between the occurrences of the maxima in the original time series of any two variables.

In the full text the results are presented as follows:

1- The time series of the three environmental factors and the five zooplankton groups are presented graphically.

2- The amplitudes of the above variables are presented graphically against the frequency.

3- The relevant frequencies in the environmental variables as well as zooplankton groups and species have been tabulated to deduce the common frequencies among the different variables (table 1).

4- For a given frequency (or period) the delay time of occurrence of the maxima in original time series (blooming times) of any two variables was calculated (tables 2). The negative sign indicates raw variable peak comes first, and positive sign indicates that the column variable peak comes first (table 2).

Tab. 2. Matrix of delay in months (from phase of raw var. - phase of column var.) for the cycle of zooplankton groups and some environmental variables at the periodic time of 12 months from Fourier analysis (- sign indicates raw variable peak comes first, and + sign column variable peak comes first.

variable	No.	1	2	3	4	5	6	7	8	9
Phase Angle		193.92	6.92	271.79	296.39	10.31	264.20	265.31	180.37	304.15
temp	1	193.92	0.00	-6.23	2.60	3.42	-6.12	2.34	2.38	-0.45	3.67
salinity	2	6.92	6.23	0.00	8.83	9.65	0.11	8.58	8.61	5.78	9.91
chlorophyll	3	271.79	-2.60	-8.83	0.00	0.82	-8.72	-0.25	-0.22	-3.05	1.08
totalzoo	4	296.39	-3.42	-9.65	-0.82	0.00	-9.54	-1.07	-1.04	-3.87	0.26
Ciiripede lar.	5	10.31	6.12	-0.11	8.72	9.54	0.00	8.46	8.50	5.67	9.79
Polychaetes	6	264.20	-2.34	-8.58	0.25	1.07	-8.46	0.00	0.04	-2.79	1.33
Copepods	7	265.31	-2.38	-8.61	0.22	1.04	-8.50	-0.04	0.00	-2.83	1.29
Rotifers	8	180.37	0.45	-5.78	3.05	3.87	-5.67	2.79	2.83	0.00	4.13
Titinnids	9	304.15	-3.67	-9.91	-1.08	-0.26	-9.79	-1.33	-1.29	-4.13	0.00

Conclusions

The most common periods for the different variables are 36, 12, 9 and 6 months. The 12 months is corresponding to seasonal changes, the 36 months may be related to inter-annual climate changes and periods less than 12 months are due to local changes depending on the hydrological exchange between the Eastern harbor and the open Mediterranean coastal waters in-front of the study area. The time lags of the occurrence of the maxima for each variable (groups and environmental factors) relative to the other variables at the important cycles with periods 36, 12, 9 and 6 months are calculated to expresses the response time of the different groups blooming. The cluster and correlation analyses of the different variables have also be done to show the significantly correlated ones.

References

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