CLIMATE REGIME SHIFTS OF THE ADRIATIC SEA ECOSYSTEM

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Abstract
While increased atmospheric CO_2 flux is assumed as a general warming factor, essential climatic influence in the Adriatic Sea comes through the water exchange with the Mediterranean, that reflects an air pressure variability over the wider area. Based on the pressure index and CO_2 time series we have examined the effects of climate shifts/changes to the Adriatic Sea ecosystem.
Keywords : Adriatic Sea, Primary Production, Atmospheric Input.

Introduction
Continuous increase of atmospheric greenhouse gases is the main factor of the global temperature increase. We wanted to discover the changes in the marine ecosystem triggered by climatic changes, and eventually quantify the causes and the effects in the complexity of the feed back processes of the atmosphere-sea system. Trends and fluctuations were already observed in various biotic systems in the world seas, including the Mediterranean and the Adriatic Sea [1]. Long term oceanographic records from the Middle Adriatic enable better understanding of the ecosystem response to changes of atmospheric and sea conditions through physical, chemical and biological processes. In order to analyse ecosystem response to climatic forcing, the changes and shifts of primary productivity and climatic indicators were compared and analysed.

Datasets and methods
A sea level pressure index, taken as a climatic indicator, was defined via Principal Component Analysis of the mean annual sea level pressure data over the Northern Hemisphere from the area 30^0 W- 40^0 E and 30^0 - 65^0 N, for the period 1948-2003, from the NCEP/NCAR reanalysis (http://www.cdc.noaa.gov). The obtained index describes the mean annual pressure variability over the central northern Atlantic [2]. A warming index is defined through a detrended series of relevant CO_2 fluxes in the atmosphere. For the ecosystem index, the primary productivity data since 1962, collected monthly at the open sea station Stončica (STS) and the coastal station Kaštela Bay (KBS) were analysed (unchanged method over the analysed period). Regime shifts were detected via the SARS method proposed by Rodionov [3]. The locally-weighted scatter plot smoothing (LOWESS) method was used for displaying nonlinear trends.

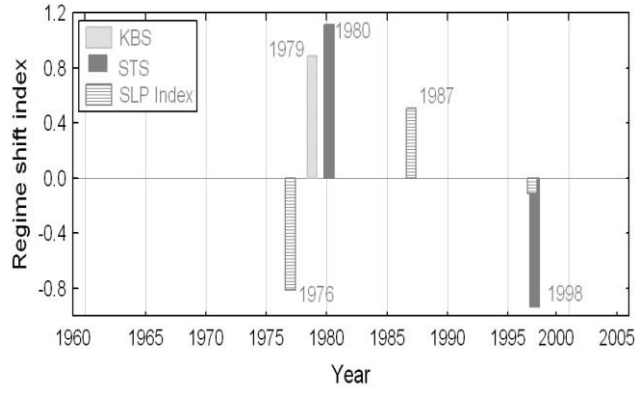

Fig. 1. Primary productivity regime shift and sea level pressure indexes.

Results and discussion
At a multi-decadal scale changes of productivity in the coast and the open sea show a high degree of correspondence (r=0.70; n=41; p<0.001); although coastal waters have few times higher productivity rate. Coherent fluctuations point to the influence of a common external forcing. The application of the LOWESS method on productivity reveals non-linear relationships, and distinguishes the three different periods (1962-1979), (1980-1997) and (1998-2005) in which the mean value and dispersion is different in amount and sign from a normal period (Figure 1).

Till 1979, at open sea, there was no significant trend of primary productivity. In the same period an increase of primary productivity was observed at KBS, but primarily due to an increase in the first ten years, which had huge anthropogenic load. An abrupt primary productivity regime shift was observed in 1979 in the coastal waters and a year later at open sea. While trends could be partly influenced by eutrophication, the abrupt change in the atmosphere over the Northern Hemisphere probably caused productivity multi-decadal changes in the Adriatic Sea. The changes of climate and the abrupt climatic shifts in the atmosphere could be the forcing factors that controlled the Adriatic ecosystem dynamic. By the end of the first normal period, the abrupt jump in primary productivity occurred at STS, followed by a regime shift of the pressure index, connected to CO_2fluxes (Fig.2).

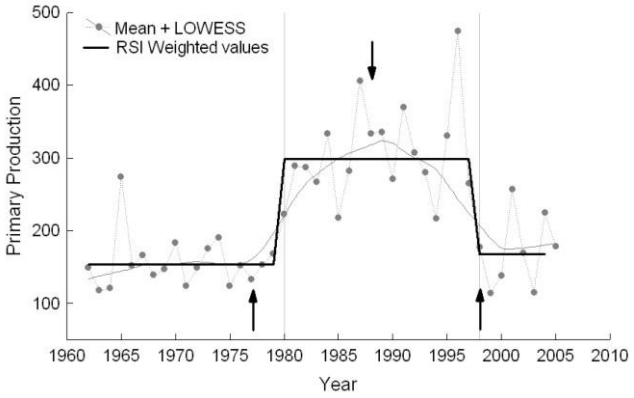

Fig. 2. Mean annual primary productivity at the Middle Adriatic open sea station (STS), RSI weighted values, and arrows indicating shifts in the atmosphere.

The warming begun around 1978, accompanied by a decrease of precipitation and an increase of the E-P value. The increase of the winter NAO index in the period 1978-1992 was recorded. This period was characterized by the shift of primary productivity. The question is, what has caused such an abrupt increase of productivity? We believe that the increase of primary productivity in the Middle Adriatic can be associated to the climatic shift. The atmospheric response to CO_2 flux jump resulted in a temperature increase. The changed pressure distribution over the northern Atlantic and wider, extending to the SE Mediterranean, has influenced the exchange between the Adriatic and the Mediterranean. This has regulated the corresponding salinity fluctuation, nutrient enrichment and consequently the primary productivity changes/shifts in the Adriatic.

References
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