Changes in the marine ecosystems of the northern Adriatic Sea

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Introduction

Combined effects of the anthropogenic impact and regional climate changes are causing modification of physical and chemical oceanographic characteristics of the northern Adriatic Sea (NAd), influencing its biota. These modifications are documented by a growing amount of data, so that their re-analysis is important to better clarify the current state of this marine ecosystem and to direct future research.

Objectives

Analyzing long time series trends and previous findings we present an overview of the changing trophic conditions of the northern Adriatic Sea.

Influence of climate changes on oceanographic properties

An increasing trend of the sea surface temperature of the open NAd waters has been found, as shown in the figure. An unusually marked increase in salinity since the 2000 was evidenced from the analyses of trends over the years 1976-2005 in the entire NAd [1] and 1972-2009 in the eastern NAd [2]. This increase was attributed both to reduced river outflows and to a more sustained inflow from the central Adriatic.

Trends of eutrophication pressure

Overall, a significant decreasing trend of PO4 and an increasing trend of DIN (not shown) and of DIN/Po4 ratio have been detected during the last four decades. The DIN increase was very probably due to an enhanced reduction of the P04 concentration after 2000, already observed since the late 1980s, limiting further the phytoplankton growth and resulting in a more marked accumulation of unused DIN [4].

Changes in benthic communities

Mass mortalities of benthic macrofauna have been reported in particular during the 1970s and 1980s, as a consequence of repeated events of hypoxia and anoxia. The largest mortalities were due to the anoxic crisis of 1974, 1977, 1983 and 1989 [5]. In the last decades no mass mortalities due to hypoxia at regional scale were reported. A 20 yr long study carried out in the eastern NAd showed that soft-bottom polychaetes declined after the anoxic event of 1989 leading the macrobenthic communities to an instability with the dominance of bivalves [6]. During the slow recovery the contribution of bivalves to the overall diversity and abundance decreased gradually.

Consequences for the ecosystems

Climatic fluctuations and variations of the anthropogenic pressures during the last decades had relevant consequences for the ecosystem as:

- reduction of the phytoplankton biomass due to a decrease of phosphorus concentrations, particularly in the western NAd; a general trend toward small size species
- macrobenthos recovery in area previously impacted by eutrophication;
- decreasing trend in total biomass of target demersal fishes and in small pelagic fish (e.g. anchovy) catches;
- reduction of the average trophic level of fish community;

On the whole, these changes are indicative of an oligotrophication process, similar to what happens in other European seas like the Danish Straits, the Scottish estuary, the northeastern Black Sea.

Study area and general circulation

The study area is the shallow (<50 m) northern Adriatic Sea, the land locked northernmost region of the Mediterranean. The NAd is influenced by coastal currents which are part of the Black Sea cyclonic gyres, while the warm and salty Eastern Adriatic Current (EAC) flows along the eastern coast. During cold winters the area is a site of formation of dense waters which flow southwards. In spring-summer, semi-permanent cyclonic and anticyclonic subregional gyres develop, which control large outflow of freshened waters, and thus reducing the water exchange with the central Adriatic. These gyres are larger in summer, with a development of the eastern Adriatic Coastal Current (ICCC) [3]. This high intensity of the ICCC coincided with events of near anoxia, anoxia and/or mucilage events.

Inputs of continental freshwaters and nutrients

In the Gulf of Trieste, the Po River freshwaters showed significant long term oscillations and a marked decrease in the most recent period 2003-2007. At the same time, the Adige River and other minor rivers in the NAd showed a constant decrease, with flows substantially reduced (33%) with respect to the mean values typical of the 1980s. Consequently, the river nutrient discharges in the NAd, estimated for the period 1998-2002: 295,000 t yr⁻¹ for total N, 11,100 t yr⁻¹ for total P and 196,000 t yr⁻¹ for SiO₄ decreased by 50-70% during the extremely reduced freshwater inflow in years 2005-2007 [7].

Changes in plankton abundance

In the Gulf of Trieste (CI-LTER site), the analysis of a long and continuous data set collected 1990-2008 evidences significant changes in both abundances (Fig. 2) and phytoplankton composition [8]. The major shift in abundance was detected in 1993-1994, mainly due to a dramatic decrease of phytoplankton biomass. Moreover in the eastern part of the Gulf of Trieste a shift in mesozooplankton biomass was found [9].

Changes in fish communities

An increasing trend of thermophilic taxa, which appear to expand northward, has been reported in the Adriatic Sea [11]; concurrency with changes in oceanographic properties. Analysis of datasets independent of collected after the 1980s evidences that fish community has not recovered in the last two decades, and actually a decreasing trend is still going on in the total biomass, in the average trophic level of fish community (see figure). Analyses based on catches confirmed that: since mid 1980s - small pelagic catches were also not recovering [12].

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References

[1] Gianini et al., 2012. River flows for periods in which significant temporal trends were detected by Mann-Kendall Test (test Z, n = number of data, p = probability) [7].


[4] Mazza et al., 2012. River flows for periods in which significant temporal trends were detected by Mann-Kendall Test (test Z, n = number of data, p = probability) [7].


