Northeastern Mediterranean climate and zooplankton variability

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Abstract

The Mediterranean Sea is influenced by large-scale climate patterns within the global climate system, and appears to be one of the areas potentially most affected by climate change. The climatic changes recorded in the Northern Hemisphere during the last decade, and the sensitivity of the Mediterranean Sea to climate variability, suggest the possibility of identifying causal links between climate change and alterations in the marine biodiversity of Mediterranean basin.
Our previous analyses (Conversi *et al.*) indicate that the copepod community in the Gulf of Trieste is undergoing a number of changes between the two periods 1970-87 and 1988-2005, with an overall increase in abundance (+ 93%), accompanied by a shift toward smaller species, and the rise (*Oncaea spp.* and *Euterpina acutifrons*) or decline (*Pseudocalanus elongatus, Clausocalanus spp.*) of several species.
The purpose of this work is to investigate whether there exists a relationship between the variations in the copepod abundance in the Gulf of Trieste and large-scale climate pattern. To do this we have used a set of climate indices relevant for the region, or large-scale physical variables (North Atlantic Oscillation (NAO), East Atlantic Pattern (EA), the Scandinavia Pattern (SCA), and North Hemisphere Temperature (NHT)), and the abundance of the copepod species which showed an increasing trend in our previous analysis.

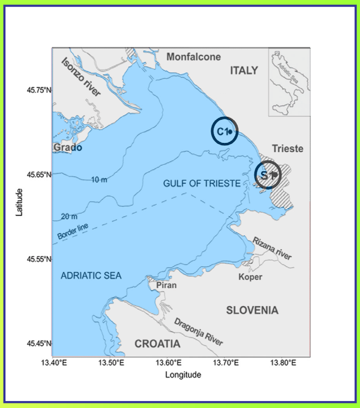

Fig.1: The Gulf of Trieste, north Adriatic Sea: location of the mesozooplankton sampling station (C1), and of the SST measuring site (S1).

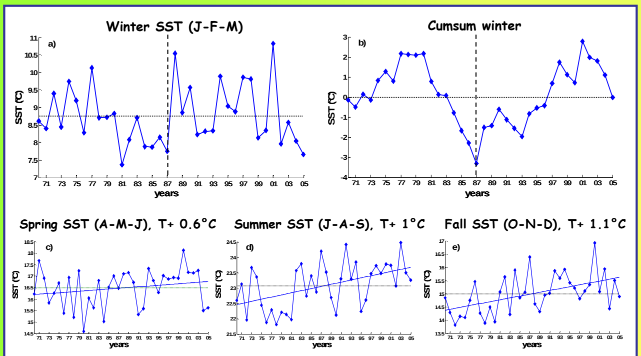

Fig.2

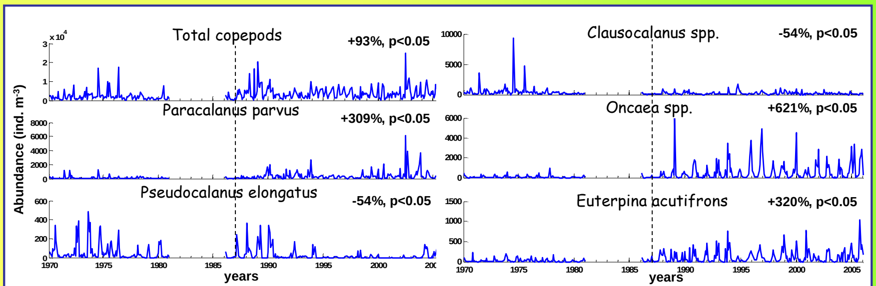

Fig.3 (p derived from Wilcoxon-Mann-Whitney test; % increment calculated on geometric means)

A changing ecosystem

- Biological data used: 36 year (April 1970 – December 2005, 5 year gap from January 1981 to February 1986, incl.) of monthly copepod abundances (number of individuals m^{-3}), comprising 22 copepod species and taxa;
- for this work we have chosen as indicator the winter SST because the Mediterranean circulation is mostly forced by the winter climate (Korres et al., 2000).
- the cumulative sum technique (Beaugrand *et al.*, 2003) indicates that the period of change in the water column starts in 1988. We therefore have chosen year 1987 as delimitator for the 2-period analyses, with the first period (T1) being 1970-1987 and the second (T2) being 1988-2005 (Fig. 2).

The comparison of the two periods shows:

- long-term changes: almost all species increase with an overall abundance doubling in the period T2 vs T1 (Fig. 3);
- as a results, the composition of the copepods community differs substantial after 1987 (Fig. 4);

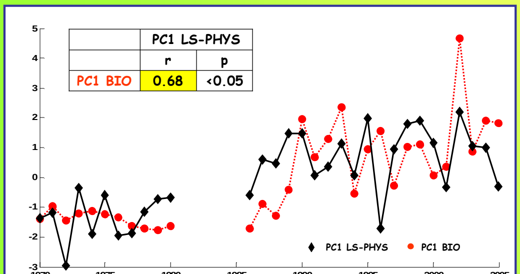

Fig.5

	total variance	(PC1) 45%	(PC2) 25%	(PC3) 20%
LS-PHYS	NAO	0.36	0.66	0.65
	EA	0.31	-0.75	0.58
	Scandinavia	-0.61	0.02	0.44
	NHT	0.64	0.01	-0.22

Table 1. Percentage of the total variance associated with the first three principal components (PCs) of the analyzed time series. The contribution to each PC formation, as indicated by the correlations coefficients of variables used in each PCA, is shown by significant coefficients.

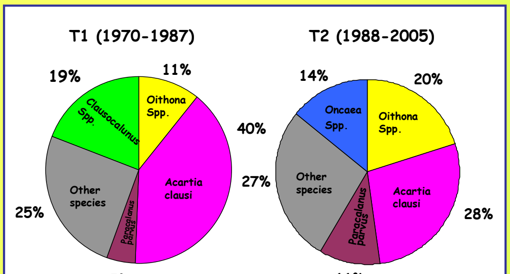

Fig.4

Fig.2. a) Winter SST, with long-term mean (dotted) line; (b) Winter SST cumulative sums. For comparison, the (c) Spring, (d) Summer, and (e) Fall SST values are reported, with respective long-term mean (dotted) and trend (solid) lines. The vertical dashed line separates the two periods identified by the cumulative sum techniques.(Conversi *et al.*).
Fig.3. Long term variations. The vertical dashed line separates the two periods identified by the cumulative sum techniques (Conversi *et al.*).
Fig.4. Percent composition of copepod species during the periods 1970-87 and 1988-2005. Only species which represent ≥ 5% are reported. Note that overall abundance is 93% larger in the second period.
Fig.5. Main pattern of long-term variability of the studied time series represented by the first PC: LS-PHYS (black line), and BIO (red line)

Large scale climate vs. zooplankton

- The North Adriatic Sea is influenced by a number of climate patterns, whose relative strength is variable in time. As large scale physical data (LS-PHYS), or proxies for the climate control over the region, the following indices were initially selected: NAO, EA, SCA, and NHT;
- we used principal component analysis (PCA) to investigate the inter-annual variability of LS-PHYS, and of a subset of copepod species (*Oncaea spp., Paracalanus parvus, Temora stylifera, Euterpina acutifrons,* and *Calanus helgolandicus,* BIO) that showed inter-annual variations based on the cluster analysis performed by Kamburska and Fonda (2006);
- the first component (PC1) of the climate indices represents 45% of the total variance (Table 1). As it can be seen by the principal component coefficients for all original climate variables (Table 1), it is mainly influenced by the SCA and NHT;
- highly significant correlations between the inter-annual variability of climate and zooplankton abundance are evident in Fig. 5 (r=0.68, p<0.05)

Conclusions

The several changes that take place in the copepod community in the Gulf of Trieste suggest an ecosystem wide response to some type of large scale physical forcing.
A literature review indicates, in fact, the existence of peculiar physical conditions at the end of the 1980s, which preconditioned a basin-wide alteration in the 1990s (for Mediterranean circulation, see Demirov and Pinardi, 2002).
These two hypotheses – circulation changes *vs.* system warming - are not mutually exclusive, and the relative importance of each one, and specifically of endogenous (such as changes in the species phenology) *vs.* exogenous (such as advection) factors should be verified via specific target studies.
The preliminary results given by the PCAnalysis suggest that large scale climate factors, rather than local hydrological properties, are associated to the changes seen in several zooplankton species at the end of the 1980s.

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