Introduction

Shallow marine basins with densely populated shorelines and high levels of exploitation such as the northern Adriatic Sea are likely to have undergone significant ecological changes over the past centuries - changes that are difficult to track merely by investigating present-day ecological conditions. However, changes in molluscan death assemblages along sediment cores can be used as proxies for ecological shifts over time. We apply this approach to a sampling station in the Bay of Panzano, close to the Isonzo River mouth and not far from the major industrial harbours of Montalbanco, Trieste (Italy) and Koper (Slovenia) to help reconstruct the ecological history of a strongly impacted marina area. Combining the analyses of core data, community changes with measurements of sediment geochemistry and direct shell dating yields insights into the timing and the anthropogenic component of major ecological shifts in past centuries.

Sediment analyses

Heavy metal contamination is high, with Hg, Cr, Cu and Ni exceeding NOAA TEL threshold levels. Hg peaks in the lower part of the core, Cu, Ni and Cd in the middle part, and organic pollutants in the uppermost layers (fig. 3a).

Species richness and abundance

In total, more than 10,000 individuals were analysed and 114 mollusc species identified. The most abundant bivalve species are *Kurtiella bidentata*, *Corbula gibba* and *Acesta nitida*. *Tonna communis* and *Nassarius pygmaeus* are the most frequent gastropods. Down-core changes in species composition and abundance are conspicuous (fig. 4a, fig.5). Non-metric multidimensional scaling (fig. 6a) identifies two distinct groups in the lower part of the core, and a conspicuous community shift along the first axis in the top 50 cm. Species richness increases in the uppermost layers, but formerly abundant species (e.g. *T. communis*) declined in favor of a few opportunists (*C. gibba*, *N. pygmaeus*, fig. 4b). While a prior- and interstitial species increase in the top of the core, host-associated molluscs (*Maculina sublittoris*, *K. bidentata*) decline strongly (fig. 4c). RDA analysis reveals that species composition is mainly driven by grain size and nutrient conditions (fig. 6b).

Discussion

Despite the homogenous grain size composition at Panzano Bay, the molluscan communities vary at different sediment depths. This suggests that shifts of other environmental factors besides grain size have a strong influence on community composition.

Complex trends characterize community changes down the core. First, there are low values of species richness in the upper core layers due to a massive, and century-long contamination caused by the Isonzo mercury mine located up the Isonzo River. Second, a distinct molluscan community is identified by NMDS in the middle part of the core (40-90 cm) where the concentration of several heavy metals (Cr, Cu, Ni and Cd) reaches levels exceeding NOAA TEL thresholds.

Most changes, however, occur in the uppermost 10 cm (the last 100 years). Here, host-associated species drop rapidly, probably following a decline of their echinoderm and ascidian host populations, and resistant and opportunistic species such as *Corbula gibba* and *Nassarius pygmaeus* increase rapidly and reach peak values. RDA indicates that this trend is mainly caused by increased nutrients, although organic pollutants (PCBs and PAHs), which are strongly correlated with nutrient concentrations, may play an important role as well.

Nutrient increase can also help explain the surprising trend of rising species richness in the uppermost 10 cm (the last 40 years). The availability of more nutrients enhances the development of benthic multi-species clumps, which in turn increase habitat heterogeneity and provide niches for additional epifaunal molluscs species. In addition, effects of similar environmental regulations in the past decades and a declining fishing pressure in the Panzano Bay area could add to the described trend.

Our study shows how pollution and eutrophication, among other factors, can affect individual molluscs species and lead to marked and complex changes at community level.