Effect of Holocene environmental change on the size structure of mollusc indicator species of the northern Adriatic Sea

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Introduction and objectives

Benthic communities of the northern Adriatic Sea (NAS) have been severely affected by anthropogenic impacts during the last century. One example is the increase in relative abundance and body size of the opportunistic, hypoxia-tolerant bivalve *Varicorbula gibba* during the 20th century due to eutrophication and increased hypoxia frequency. The gastropod *Turritellinella tricarinata* (= *Turritella communis*) decreased in abundance in response to these stressors (Tomašových et al., 2020).

Size of mollusc species susceptible to hypoxia may increase in response to eutrophication but will decrease if nutrient input leads to deoxygenation (Carmichael et al., 2012).

We study size changes of *T. tricarinata* in response to anthropogenic stressors of the 20th century and compare it to those of *V. gibba*.

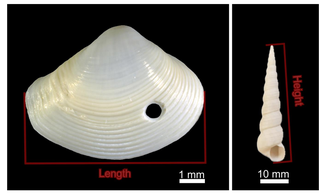

Figure 1. V. gibba *(left) and* T. tricarinata *(right). Length and height, respectively, were used for size analysis.*

Material and methods

Material comes from 1.5 to 1.6 m long sediment cores taken at stations off the Po delta, in the Bay of Panzano, and in Koper Bay. Faunal composition and size structure of *V. gibba* at stations Po 4 and Panzano were the subject of previous studies (e.g. Tomašových et al. 2020). Material from station Koper 4 comes from a new core (KOP4-21-10).

This new core is more condensed than cores from Po 4 and Panzano, enabling the study of long-term trends in size structure as a baseline for evluating changes induced by anthropogenic stressors during the last century.

The chronologic framework was provided by ^{14}C-dating of shells of *V. gibba* and *Ostrea edulis*.

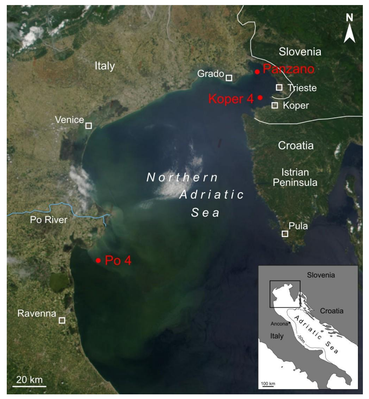

Figure 2. The northern Adriatic Sea (NAS) with locations of stations in red (modified after Gallmetzer et al., 2019).

Koper Bay: Long-term trends in size structure

The core can be separated into two lithologic units characterized by different grain size distributions. Based on shell ages they can be assigned to the transgressive (TST) and highstand systems tracts (HST) of the Holocene.

The median age of *V. gibba in* the lower part of the core is ~7000 yrs BP. The interquartile range (IQR), which is a measure of time averaging, increases upward. Densities of both species are higher in the HST than in the TST.

Size of *V. gibba* is greater in the HST than in the TST with a higher proportion of large specimens.

Size of *T. tricarinata* increases from the TST to the lower part of the HST but is smallest in the upper part of the HST.

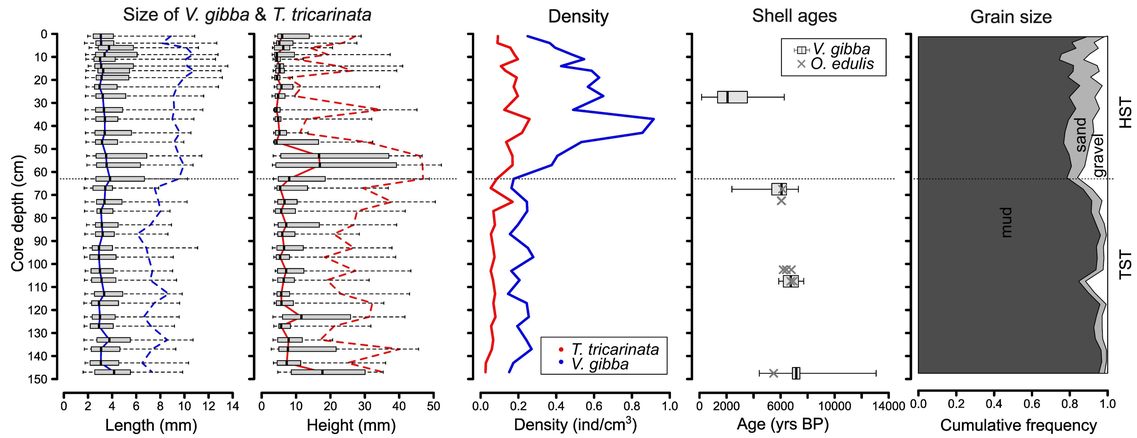

Figure 3. Size trends of V. gibba *(solid blue line: median length, dashed blue line: 95th percentile length) and* T. tricarinata *(solid red line: median length, dashed red line: 95th percentile length), density of both species, calibrated ^{14}C- ages of* V. gibba *and* O. edulis*, and grain size distribution from station Koper 4.*

Panzano and Po: Recent changes in size strucuture

Size of both species increased from the early to late 20th century at Po 4 before it decreased in the 21st century.

At Panzano size of both species is higher for the 20th than for previous centuries, although this pattern is less clear for *T. tricanata* as its size shows pronounced fluctuations. PERMANOVA (nPr = 999, F = 7.09, p = 0.012), however, confirms distinct size structure in the 20th century samples. Within the 20th century size decreases, as opposed to Po 4.

Larger sizes attained during the 20th century at both stations exceed sizes from the late HST of Koper 4.

The concentration of total nitrogen (TN) increases in the 20th century and exceeds the levels observed in older strata.

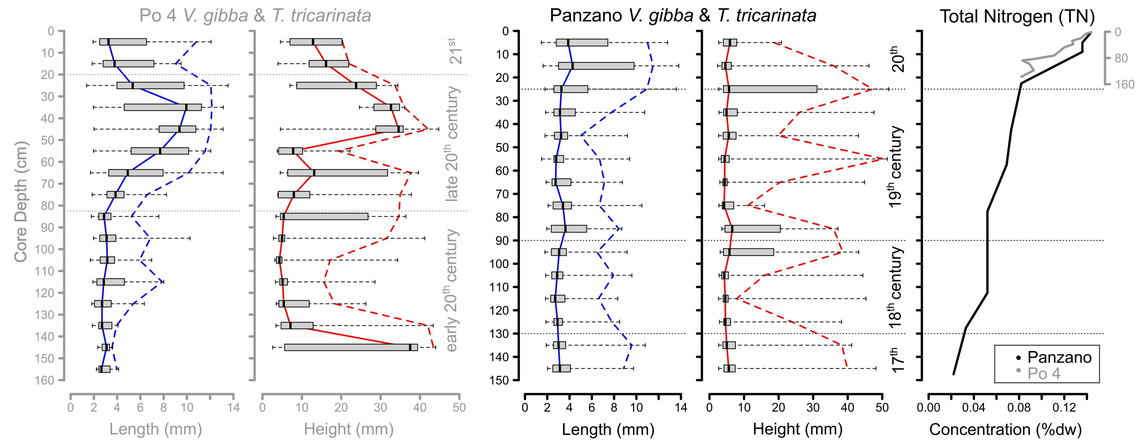

Figure 4. Size trends of V. gibba *(solid blue line: median length, dashed blue line: 95th percentile length) and* T. tricarinata *(solid red line: median length, dashed red line: 95th percentile length) from stations Po 4 and Panzano. TN concentration from both stations indicating increased nutrient levels during 20th century.*

Take-home message

In Koper Bay, *V. gibba* and *T. tricarinata* show opposing trends in size structure from the TST to HST. Further studies are needed to determine the drivers of these changes. During the last 7000 yrs, sizes in Koper Bay remained mostly below sizes observed in the 20th century at Panzano and Po 4.

V. gibba increased in size in response to eutrophication (see TN concentration) and increased hypoxia frequency during the 20th century, probably due to a combination of enhanced food supply and ecological release from predation and competition (Tomašových et al., 2020).

Size of *T. tricarinata* increases in response to eutrophication of the 20th century, but increased hypoxia frequency during the late 20th century (Justić, 1991) probably also led to local decreases in size as seen at Panzano. Thus, *T. tricarinata* shows a dual response to eutrophication and related habitat degradation through hypoxia.

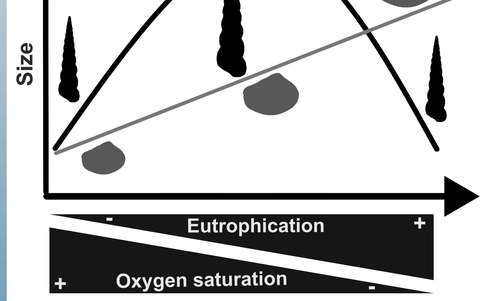

Figure 5. Scheme showing how size of V. gibba *(grey) and* T. tricarinata *(black) changes with the degree of eutrophication and oxygen saturation.*

References

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