

**Subject:**

Authors' Response to RC1 (Paolo G. Albano)

**Text:**

Thank you for the comments in the public review process of our paper. The suggestions and the discussion on the uncertainties applied by our approach will improve the manuscript. Please find our responses to the comments below in blue.

This paper addresses the effects of natural and human environmental modifications during the last 2000 years in an area in the southern Danube river delta and to its endemic so-called Pontocaspian species. The study highlights how such modifications, and especially the most recent human-induced ones, are causing the local eradication of these species. Given that their distributional area is very restricted, the loss of this habitat and its endemic species is of major conservation concern. By highlighting the historical causes of habitat modification, the study offers practical solutions fitting the growing need of conservation studies based on baseline data and understanding of the area temporal dynamics and puts paleoecological data into an effective framework for conservation decision making. I have few comments mostly to invite the Authors to discuss the uncertainties implied by some of the limitations of their approach.

- line 58-59: as it is written, the sentence suggests that conservation paleobiology studies like those cited do not bear a policy relevant conservation message; I assume that this is unintentional, because in my opinion those papers do offer a practical conservation message. Some rewording may be necessary.

**Answer:** We checked the sentence carefully again. We will rephrase it to:

'Altogether the data should not only focus on scientific observations and understanding, but also contribute to conservation policies with relevant proposals for ecosystem management (Albano et al., 2016; Helama et al., 2007; Kosnik and Kowalewski, 2016; Martinelli et al., 2017; Vegas-Vilarrubia et al., 2011).'

- line 130: please specify the core diameters. Please provide more details on how the cores (especially the long ones) were collected.

**Answer:** We will give more detailed information and change line 130-131 to:

'We performed facies and fauna analyses on eleven shallow sediment cores. The lakes are very shallow and did not allow boats with piston core facilities. We manually took PVC cores with a diameter of 7.5 cm and lengths between 0.5 m and 1.95 m at water depths of 1.0 to 3.5 m during two expeditions in October 2015 and July 2016 (Fig. 1b; Table 1). By pushing the pipes in the soft sediment and ensuring they were sealed we were able to create a vacuum when retrieving the cores. Deformation along the core edges was minimal. Sedimentary structures like horizontal beddings were conserved within the sediments proving that the sampling method was successful and representative for changes through time and space of the depositional environment.'

- line 135: the Authors should be very careful in using the date of first occurrence of a non-indigenous species to date an horizon in a core because time lags in first detection are the norm (Crooks 2005). Due to such time lags, the first occurrence in a core may indicate a time which is considerably before the first published record, as demonstrated for the invasive bivalve *Anadara transversa* in the Adriatic (Albano et

al 2018): the introduction history reconstructed from cores was three times longer than based on the first published occurrence report. This uncertainty must be acknowledged. Moreover, the Authors should write in greater detail the introduction history of *Potamopyrgus* in the studied region (rather than in Europe in general) providing the year of first report for the site closest to the study area.

Crooks JA (2005) Lag times and exotic species: the ecology and management of biological invasions in slow-motion. *Ecoscience* 12 (3): 316-329.

Albano PG et al (2018) Historical ecology of a biological invasion: the interplay of eutrophication and pollution determines time lags in establishment and detection. *Biological Invasions* 20 (6): 1417-1430.

**Answer:** We acknowledge the uncertainty of using a first occurrence date of certain non-indigenous species. We checked again the literature carefully for the first report of *Potamopyrgus* in our region of study, Romania and the Black Sea, which appears to be later than for other parts of Europe: around 1951-1952.

We will therefore add and change information on the introduction history of *Potamopyrgus* after line 154:

'Finally, the first arrival of the invasive snail *Potamopyrgus antipodarum* (Gray, 1843) in Europe provided an additional maximum age tie point. The species is originally from New Zealand, and the chronology of its introduction in other parts of the world is well known. It was introduced around 1859 to England, in 1872 to Tasmania, in 1895 to mainland Australia, in ca. 1900 to the European mainland (Ponder 1988), and in 1987 to North America (Zaranko et al. 1997). The first reports of *P. antipodarum* from sites closest to the RLS come from Romania in 1951 (Son 2008) and the Black Sea in 1952 (Gomoiu et al 2002).'

Gomoiu, M.-T., B. Alexandrov, N. Shadrin and Y. Zaitsev. 2002. p. 341-350. In: E. Leppakoski, S. Gollasch and S. Olenin [eds.]. *Invasive Aquatic Species of Europe. Distribution, Impacts and Management*. Kluwer Academic Publishers, Boston.

Son, M.O. 2008. Rapid expansion of the New Zealand mud snail *Potamopyrgus antipodarum* (Gray, 1843) in the Azov-Black Sea Region. *Aquatic Invasions*, 3(3): 335-340.

Therriault, T. W., Weise, A. M., Gillespie, G. E., Morris, T. J., & Department of Fisheries and Oceans, Ottawa, ON(Canada); Canadian Science Advisory Secretariat, Ottawa, ON(Canada). (2011). Risk assessment for New Zealand mud snail(*Potamopyrgus antipodarum*) in Canada (No. 2010/108). DFO, Ottawa, ON(Canada).

Zaranko, D. T., Farara, D. G., & Thompson, F. G. (1997). Another exotic mollusc in the Laurentian great lakes: the New Zealand native *Potamopyrgus antipodarum* (Gray 1843)(Gastropoda, Hydrobiidae). *Canadian Journal of Fisheries and Aquatic Sciences*, 54(4), 809-814.

- The number of <sup>14</sup>C dated samples is really small and, according to S5, is limited to one sample per core (generally at the bottom, I assume to constrain the maximum age). However, there is no reference to time averaging and mixing when interpreting the results of this approach. Please, also specify which species you <sup>14</sup>C dated and provide greater detail the calibration procedure.

**Answer:** Although the amount of <sup>14</sup>C dated samples is very small, we believe that the combination of different dating methods is strong enough to create our age model (<sup>210</sup>Pb stable isotopes, <sup>14</sup>C dating, magnetostratigraphy, the introduction of *Potamopyrgus*). Indeed the samples were taken at the bottom to constrain the maximum age with C14 and at the top to constrain a younger age with Pb210. Furthermore, the reviewer is right that we should refer to the problem of time averaging (Kidwell, 2002). We will add a sentence after line 232:

'The age control does not allow detailed insights into reworking through bioturbation and time averaging. However, the consistency of assemblages and observed trends indicates in general low rates of reworking. This suggest that the active layer in most of the system has been very shallow.'

For more information on <sup>14</sup>C dated species we will add another table, Table S9:

Core	Depth (cm)	Species	Amount of specimens	Weight (in mg, min. 20 mg)
C-03	114	<i>Lentidium mediterraneum</i>	6	40
C-06	120	<i>Ecrobia maritima</i>	16	32
C-07	78	<i>Monodacna</i> sp fragments	8	30
C-07	137	<i>Dreissena polymorpha</i>	1	31
C-10	66	<i>Dreissena polymorpha</i> fragments	6	32
C-13	120	<i>Lithoglyphus naticoides</i>	1	21
C-13	180	<i>Ecrobia maritima</i>	15	30

- line 173: please define “GeoEcoMar”

**Answer:** We will change line 173-174 to:

‘Van Veen grab and dredge samples from 77 stations obtained during a 2017 survey of GeoEcoMar (the National Institute for Research and Development of Marine Geology and Geoecology, Romania) were investigated for living molluscs.

- line 180-182: apparently there is no reference to the confounding factors such as time-averaging and mixing-bioturbation when interpreting the results. Please note that focusing on specimens poorly affected by taphonomic processes (lines 180- 182) does not provide any guarantee against their effects because shells which get quickly buried may display very low taphonomic damage and be mixed in the sediments due to e.g. bioturbation. See also Tomasovych et al (2018) for an example of species co-occurrence in a core which mask differential variation of production in time.

Tomasovych et al (2018) A decline in molluscan carbonate production driven by the loss of vegetated habitats encoded in the Holocene sedimentary record of the Gulf of Trieste. *Sedimentology* 10.1111/sed.12516

**Answer:** Thank you for that comment The reviewer has very valid point here and our approach is in this sense somewhat crude. We will add after line 182:

‘We are aware of confounding processes that may result in mixed assemblages with specimens that have a similar preservation signature. Species that burrow into a layer where good preserved molluscs from an earlier period are present may yield the same final good preservation status (Tomasovych et al., 2018). As we cannot correct for that in the analysis it is treated in the discussion on the interpretation of the results.’

We will add in the Discussion after line 475:

‘It is also known that taphonomic filters do not always provide a guarantee against the effect of taphonomic processes. Shells can quickly get buried by sediment and therefore show little taphonomic damage, but still get mixed in the sediments afterwards due to bioturbation (Tomasovych 2018). Only large scale dating of shells with very accurate dating methods might solve this issue, yet the existing dating techniques are not accurate enough to address this issue.’

- line 354: please specify if the Pontocaspian species you did not encounter alive survive elsewhere.

**Answer:** We will add in the discussion (after line 494):

'We are uncertain as to the present day occurrence of Pontocaspian species *Clathrocaspia knipowitchi* and *Adacna fragilis*, even though we did find paired bivalves of the latter species in beach material along the Taganrog Bay (Sea of Azov in 2017 suggesting it is alive there. No recent records of living *Hypanis plicata* exist for the Black Sea Basin, but fresh material has been found along Caspian shores (Wesselingh et al., 2019)'

- Fig. 6: I appreciate this figure which shows the studied organisms.

**Answer:** Thank you.

- Supplements: please list the species in systematic (and not alphabetic) order (e.g. in S2, S7). Note that the file and sheet naming sometimes do not match (e.g. S2 and S3, S7).

**Answer:** We will change both supplements accordingly.