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Editorial: Highly intervened estuaries: impacts, dynamics and system responses

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Editorial on the Research Topic
Highly intervened estuaries: impacts, dynamics and system responses

1 Background

Estuaries are among the most degraded and threatened environments worldwide (Scown et al., 2023; Syvitski and Saito, 2007). Highly intervened estuaries with altered environments are the result of human-engineered interventions (e.g., sluice gates, jetties, dikes, impoundments, training walls, port facilities, and dredging), land reclamation, changes in upstream land use, and human-induced pollution (e.g., Nichols et al., 1986; Lotze et al., 2005; Pye and Blott, 2014). Human interventions have modified the hydrodynamics, morphology, and geochemistry of these systems, leading to large deviations from the expected natural state and functioning (e.g., Jiang et al., 2012; Brunier et al., 2014; Zhu et al., 2017; Zarzuelo et al., 2018; Wang and Liu, 2019; Van der Spek and Elias, 2021). Such deviations exhibit non-linear patterns, adding greater complexity to the dynamics of estuarine systems under climate change scenarios. Moreover, anthropogenic actions have altered the estuarine capability to adjust to the environmental change, including responding to increased pressures in the context of climate change. As a result, highly intervened estuaries exhibit a broad range of anomalous responses, including changes in circulation patterns, disturbances in mixing conditions, accelerated siltation, closure of distributary channels, shifts in residence time, severe shoreline retreat, estuarine turbidity maximum zone changes, and the accelerated loss of ecosystem services (e.g., filtering and nutrient recycling) (e.g., Yang et al., 2003; De Jonge et al., 2014; Yang et al., 2015; Restrepo et al., 2020; Guo et al., 2021).

Despite decades of human interventions in these estuarine ecosystems, the interactions between the different impacts, their effects, and the resulting dynamic response are still not fully understood and are becoming even more complex because of the multitude of anthropic pressures (Guo et al., 2021; Dunn et al., 2023). Human interventions lead to synergic effects, triggering not just differential responses in the estuarine components but also on different timescales (Yang et al., 2003; Van der Spek and Elias, 2021). Such a level of

complexity raises questions about the degree of loss in ecosystem function and services, the resilience and capacity of assimilation or recovery, and the existence of physical, chemical, and ecological thresholds required to manage and restore highly intervened estuaries.

This article Research Topic highlights the analysis of altered processes in estuaries; brings insights into the responses to human disturbances, considering varying timescales and effects in the different components of estuarine systems; and promotes discussion about management and restoration strategies in highly intervened estuaries. The article Research Topic includes original research papers dealing with *i*) morphological and hydrodynamic responses of estuarine systems, considering different scenarios of engineered intervention and timescales; *ii*) assessment of significant changes in natural functions of estuaries (i.e., nutrients cycling, pollutant filtering, and critical habitats) after human interventions; *iii*) physicochemical degradation in estuaries triggered by heavily polluted river inputs and basin-scale processes; and *iv*) potential strategies to restore and recover ecosystem function and services in degraded estuarine systems.

Specifically, in this article Research Topic, [van Maren et al.](#) present the development and application of a methodology to estimate the estuarine response timescales against human interventions using available morphological and hydraulic data. [Velasquez et al.](#) offer a detailed comparison of the effects on hydrodynamic and morphological patterns in tidal inlets derived from coastal protection interventions (from gray to green infrastructure). [Gallo et al.](#) and [Leyva et al.](#) provide a socio-ecological assessment of two heavily altered systems, applying a multi-dimensional approach, that highlights the sources and drivers of pollution and degradation, the need for preserving and restoring critical habitats, and the barriers and gaps to obtain sustainable development. Overall, this article Research Topic spotlights the response time and magnitude of a system to human interventions, as determined by the processes driving the change, the size of the system, and the magnitude of such interventions. Nevertheless, distinctive effects must consider the unique patterns of each specific

site. The Research Topic also highlights the interest in addressing approaches aimed at recovering and increasing the environmental resilience of these valuable ecosystems.

Author contributions

JR: writing–original draft and writing–review and editing. AN: writing–review and editing. BM: writing–review and editing. JR-A: writing–review and editing. MB: writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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