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Classification of estuarine states in temporarily open-closed estuaries using network analysis.

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Abstract

Temporarily open-closed estuaries are driven by the natural seasonal cycle of rainfall and associated catchment flows. Because of the variability of catchment flow intensity and volume, the ecosystem water quality parameters and associated states fluctuate broadly. These states may be exacerbated or dampened by development-associated pressures in catchments, which can alter the food-web dynamics in the estuary. Despite this, the association between food-web dynamics and physical state remains unquantified for most South African estuaries. This study addresses this issue by linking physical ecosystem state to food-web functioning in an impacted case study system. Empirical food-web networks were built and solved across seventeen time steps using a Linear Inverse Modelling (LIM) approach, and specific Ecological Network Analysis (ENA) metrics were obtained for each. Time steps were assigned to either a “Poor” or “Fair” state using an existing water quality framework. An approach comprising classification trees and random forest models yielded the suite of ENA metrics which best predicted which state the ecosystem was in, thereby depicting how important functional parameters are linked to ecosystem state. While many of the investigated ENA metrics could effectively classify the ecosystem states, a combination of just two was required to attain an interpretable and accurate classification: flow diversity and the ratio of detritivory to herbivory. The most common interactions between ENA metrics outlined how different scenarios of energy flow in the food-webs were linked to ecosystem state. These comprised of flow diversity, ratio of detritivory to herbivory, average path length and average trophic level. For generalization to other systems, optimization of LIM model solutions and inclusion of data from additional systems are needed. Nevertheless, the distinction between poor and fair water quality was effectively described by system-level ENA metrics, highlighting the role of physical conditions in influencing estuarine ecosystem dynamics.

Keywords

Estuaries, Ecological Network Analysis, Food-webs, Ecosystem Modelling