

## **Sustainable management of harbours : a numerical approach for the assessment of waters quality**

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Within the Water Framework Directive (WFD), harbours must reach or maintain the good ecological potential, being classified as heavily modified water bodies. To fulfill this task and to comply the Marine Spatial Planning (MSP) principles, port managers have to monitor the water quality that can be compromised by the numerous activities including the realization of new infrastructures. The port of Civitavecchia, located on the central west coast of Italy, is undergoing to major structural changes to become one of the first ports of the Mediterranean in terms of passenger traffic and goods, thus requiring the development of management tools for the predictive assessment of harbour water quality.

This study focused on the evaluation of water degradation within Civitavecchia port trough the calculation of Flushing time (FT) and the development of the new Flushing Efficiency Index (FEI).

FT was calculated through the use of a numerical model under different scenarios selected combining different weather conditions with the new port configurations. FT values was then used to estimate the FEI for the evaluation of the improvement (positive values) or the deterioration (negative values) of water quality in the different zones of the port.

The increase in the harbour basin size due to the embankment extension results in high values of FT, particularly in the inner part of the port, in accordance with the highest values of the Enrichment Factor (EF) of the trace metals found in the sediment. The correlation between FT and EF confirms that renewal time can be used as a proxy to evaluate the water quality conditions in the harbour basin, as also stated by the WFD guidelines. Also the results of FEI calculation indicate the potential occurrence of water degradation due to the embankment extension. Otherwise, the realization of a second entrance in the southern part of Civitavecchia port produces FEI positive values, highlighting a drastic improvement in harbour water renewal.

Consistent with Blue Growth and Bluemed initiatives, the new tools developed in this study support the sustainable management of port activities, thereby also contributing to the development of new "blue jobs."