Sustainable port maintenance strategies - trade-offs between dredging cost and port call efficiency

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Conference theme number(s): 5

Introduction: Sedimentation affects water depths in port basins and port water areas. This may result in partial or full access restrictions which impacts a port's performance. Sediment management strategies in ports are typically aimed at maintaining desired accessibility levels against minimal cost. While there is a range of sediment management measures available (i.e. bypassing, sediment traps, current deflection walls, bubble screens, sailing through fluid mud, etc), dredging is still a key component of most sediment management strategies.

Especially in busy and sedimentation-prone ports, dredging can be a significant component of the port's operating cost. From a port manager's perspective these operating costs are not only related to the dredging works, but also to the dredging-related down time. So far an integral approach that quantifies the trade-offs between dredging cost and port call efficiency does not yet exist. Next to costs, port managers are increasingly confronted with the need to include sustainability into their trade-offs.

This paper discusses a method that links dredging efforts and port performance, as a function of sedimentation rates and accessibility. The approach allows to include energy use and emission footprints.

Methods: Discrete event simulation is an increasingly common tool to investigate the performance of dredging strategies [1]. Likewise port accessibility, as a function of currents and tides, is regularly investigated with discrete event based approaches [2]. So far, however, a combination of both approaches that would allow to quantify the overlaps between maintenance dredging and port operations for different strategies, has not yet been published.

In our approach we schematise ports with a graph that represents the port's water transport network. The nodes and edges of the network can contain physical properties such as bed level, water level, currents, sedimentation rates etc. Through accessibility criteria, we can derive (horizontal and vertical) tidal windows and assess how these affect the port's performance (Fig 1 – right). At the same time sedimentation and maintained-bed-level criteria can trigger dredging activities (e.g. trailing suction hopper dredging, water injection dredging, grab dredging, plouging); aimed at collecting the accumulated sediments and return the water depths to the desired levels (Fig 1 – left).

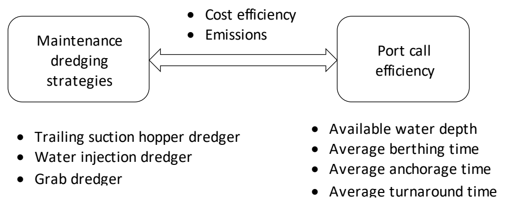

Fig. 1: Trade-off between maintenance dredging strategies and port call efficiency

By simulating the port processes and dredging activities on the same network, we can evaluate which dredging strategy is most cost effective, both in terms of minimal dredging costs and minimal disruption of the port's operations. Through vessel resistance calculations, we estimate the energy that is needed for both the dredging activities and the in-port manoeuvring of the cargo vessels. This allows us to include the sustainability of maintenance strategies, in this paper mainly in terms of energy footprints and emissions, into the above-mentioned tradeoff [3].

Results: The obtained result of this study is a trade-off analysis framework that aids the comparison and selection of the maintenance dredging strategies for a given port, taking cost-efficiency and sustainability criteria into account.

Discussion: The proposed framework enables port operators and marine contractors to design port maintenance strategies that minimize both dredging costs and port disruptions. The method includes sustainability through emission footprint estimates.

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