SHIP WAVE EFFECTS IN TIDAL WATERWAYS: PERSPECTIVES FROM AN INTERNATIONAL WORKSHOP

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INTRODUCTION

Coastal and estuarine waterbodies have always been important to the socio-economic development of societies, not least due to their provision of access to world trade. The movement of ships through water is associated with the generation of water surface disturbances which can largely be described by two distinct wave systems with long-period and short-period components, respectively; both wave systems can propagate to the waterway edges where they interact with the natural and built environment (e.g., Maynord 2004), often to adverse effect. The magnitude and frequency of detrimental impacts is becoming ever more evident in estuarine and coastal waterways around the world. In fact, ships can fundamentally alter the loading regimes and wave energy spectrum in sheltered water bodies (e.g., Soomere 2005, Muscalus and Haas 2022). Recreational and planing craft typically cause short-period secondary waves. Long-period primary ship waves are generated either as leading solitons from high-speed craft (e.g., Soomere 2005) or from large deep-draught displacement vessels that can generate significant current and wave loads in the embankment areas (e.g., Maynord 2004, cf. Fig. 1). The latter case is typical for heavily trafficked coastal and estuarine waterways of high economic significance and is the primary focus here. In this paper we reflect on the current state of play with respect to ship wave effects and their management drawing on findings from an international workshop. The workshop “ShipWave 2023”, held in Hamburg, Germany on 21-23 March 2023 explored the wide range of diverse effects on bank-side infrastructural, environmental and socio-economical assets and the arising use conflicts as well as current and future strategies for the management of ship wave impacts based on the collaborative expertise of academics, practitioners and policymakers from various backgrounds and countries around the world. The novelty of the work lies in the geographical and cultural diversity of problem descriptions on this type of loading in estuaries and coastal waters that were compiled and contrasted.

Coastal and estuarine waterways are caught between the opposing objectives of maximizing economic potential for shipping and trade (economies of utilization: larger vessels, increased traffic density) on the one hand and increased pressure from legislation (e.g., in Europe, Water Framework Directive) to halt further degradation of coastal waterbodies along with a general awareness and appreciation for their environmental and ecological value. While the need to manage the impact of shipping is universally recognised, shortcomings in process understanding and available methodological and regulatory/political frameworks still hinder effective management of the waterways in relation to shipping-related effects.

ISSUES RELATED TO SHIP WAVES

The documented effects of ship waves in confined and shallow waterways are manifold (e.g., Dempwolff et al. 2022a and references therein). Ship waves can contribute to damages to bank-side civil infrastructure (e.g. rock structures, sluice gates) as well as environmental degradation through mobilization of sediments, erosion of banks and mudflats, the degradation of aquatic habitats and pollution. Examples from waterways around the world vividly illustrate the mentioned impacts. Socio-economical impacts arise from use-conflicts with other stakeholders such as fishing, farming, tourism and recreational use and can on occasion even include risk to life for other waterway users.

Figure 1 - Ship waves interact with built infrastructure and natural embankments in the Elbe Estuary, Germany.

MANAGEMENT STRATEGIES

While engineering and structural measures (primarily armouring of embankments) have been and continue to be at the forefront of managing the symptoms of ship-induced deterioration in the past, they often run counter to the interests of ecology and environment as well as being resource intensive (construction, maintenance) on estuary-wide scales. Softer engineering measures such as more nature-based solutions, the use of dredged sediment or making space for natural embankment development are often seen as more agreeable and futureproof options, however their implementation in these high-energy environments is not always trivial and questions of longevity arise. Management strategies can and should involve regulatory measures that enforce sustainable shipping practices, which to date often take the shape of de facto speed restrictions (e.g. Croad and Parnell 2002, BSH 2012) and have proven effective. Although this solution seems popular among consultants and practitioners, it is not always well received by regulators and much less by port operators due to increased transit

times and reduced capacity utilization. Other potential solutions are education and awareness raising campaigns on the impacts of shipping for waterway users. On a strategic level, there is an argument to consider the impacts of ships in the planning of future port resources. We also highlight possible future solutions, some that can realistically be envisaged from a current technological standpoint and others that require further research to assess their feasibility and practicality.

METHODS OF INVESTIGATION

In all of the discussed issues and strategies, we recognize a dedicated demand for advanced numerical prediction tools for design of mitigation measures, which have been actively developed over the past years (e.g. Dempwolff et al. 2022b, Dempwolff et al. 2023a, Dempwolff et al. 2023b), aiming to balance accuracy, usability and computational demands. Further, we review briefly existing methods, bottlenecks and outline research and development opportunities. A discussion on the applicability and shortcomings of available methods of investigation (numerical, experimental, observational and engineering methods) has shown that (benchmark) data, design guides, best-practices guidelines and standardisations are, at best, scarce. A large improvement is expected from increased data availability and further knowledge exchange. The standardization of definitions is seen as key to the developments of best-practice as well as interdisciplinary working. Large potential is seen in novel methods such as artificial intelligence, however for questions related to ship waves these are still in their infancy.

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