Water transport in groups of nonlinear wake waves from high-speed vessels

Tarmo Soomere, Kevin E. Parnell and Ira Didenkulova
Institute of Cybernetics, 12618 Tallinn, Estonia
Tel: 372 6204176 , email: soomere@cs.ioc.ee; didenkulova@gmail.com
School of Earth and Environmental Sciences, James Cook University, Townsville, Queensland, 4811, Australia, email: kevin.parnell@jcu.edu.au

Abstract:

Tallinn Bay is one of the few places in the world where high-speed ferries operate at or close to service speeds close to the shoreline, with up to 50 departures or arrivals per day. The faster vessels enter the transcritical regime (depth Froude number ∼0.9) in some places.
We report results of recent studies (2008–2009) into the properties of such wakes based on high-resolution (5 Hz, ±1 mm) water surface profiling using an echosounder in 2.5-3 m water depth, ∼100 m offshore, ∼2700 m from the sailing line. Their role in the wave energy budget and the impact on the coastal environment in terms of wave energy and power, properties of the largest waves, and potential ship-wave-induced coastal erosion are discussed.
During calm conditions, vessel generated non-broken waves of up to 1.5 m, with periods of 10–13 seconds were measured. The typical daily highest ship wave is approximately 1.2-1.3 m. Such waves add significantly to the total wave energy experienced on certain sections of the shoreline. Most of the largest waves demonstrated significant asymmetry. Vessel generated waves also have a significant effect on the morphology and sediment budget of the shoreline not only because of their large periods, but also because of their different direction of propagation compared with predominant wind waves.
We also report a new mechanism producing onshore transport of substantial amounts of water remote from the fairway in wake waves generated by high-speed vessels.
Water is transported by precursor solitons and by the largest vessel waves that normally produce water level set-up. The major mechanism of water transport, however, is connected with an elevation event that arrives in remote areas well after the precursors. It is able to carry several times as much water as the solitons and the other wave disturbances put together. Its characteristic position just before the highest wave group suggests that it may be a specific forced disturbance created by the ship motion. The backflow of this water potentially contributes to fast removal of sediment from non-equilibrium beaches by forming strong offshore-directed flow during the latter phase of the wake-wave event.