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Beach response on the interplay of two wave systems: ship wakes and winds waves

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Tallinn Bay, the Baltic Sea, experiences very intense ship traffic, with up to 70 ferry crossings each day during the high season on the Tallinn-Helsinki route. Ships frequently enter the near-critical regime and generate packets of large, highly nonlinear, at times solitonic, very long and long-crested waves that are very different from the natural wind waves in the Bay. This is one of the few places in the world where high-speed ferries frequently operate close to the shoreline and where wake-waves may have a significant effect on the morphology and the sediment dynamics on medium-energy beaches. The proportion of ship-wave energy is about 10% of the total energy of the wave field whereas during the relatively calm spring and summer season ship waves may even dominate in some sections of the coast.

The specific contribution of long ship-waves to the wave field in semi-sheltered areas is frequently equivalent to an increase to the typical wave lengths in the affected area. Conceptually, such a change in the local wave regime is similar to a case where open ocean swell reaches coastlines not previously affected and can be interpreted as a model case of a major shift of the wave climate towards longer periods.

We analyse beach profile changes resulting from the interplay of two wave systems: ship wave packets and background wind waves. These beach changes are studied experimentally during a set of measurements carried out in 2008-2009 in Tallinn Bay and analysed with respect to changes in both wave systems.

The beach profile, is presented schematically as a power function of the coordinate with an exponent b ($\sim$xb). On the basis of field observations and measurements the parameter b has been presented as a function of time and studied as a beach characteristic with respect to wind waves (significant wave height, mean sea level, wind speed and wind gust) and ship waves (ship schedule, ship types, ship wave amplitude and period) changes.

The correlation between beach parameter b and the wave properties is discussed. For example, it is shown that during storm conditions when wind waves dominate, the beach parameter b = 2/3 corresponding to Dean's equilibrium profile, while during calm days with typical wind wave height of a few cm, 1-meter high ship waves are responsible for building the beach with the beach parameter b = 1.2 in this case.