Variability in wake properties generated by high-speed ferries in Tallinn Bay, Baltic Sea

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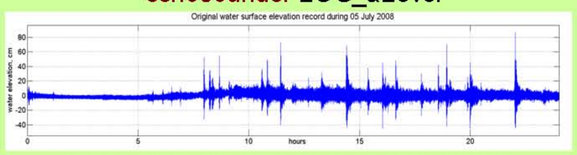
MOTIVATION

* There are many places in Tallinn Bay, where the coastal erosion processes have been observed
* Tallinn Bay hosts one of the most intense fast-ferry traffic in the world
* Wakes from fast-ferries may essentially contribute to the wave field
* The reaction of the coast to the new component of hydrodynamic activity is almost unknown

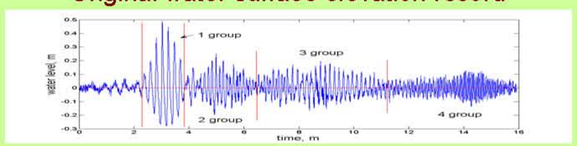
Coastal erosion on Aegna Island: is it caused by high-speed traffic?

FIELD DATA

The location of measurement site. Water surface elevation data were collected by an ultrasonic echosounder LOG_aLevel



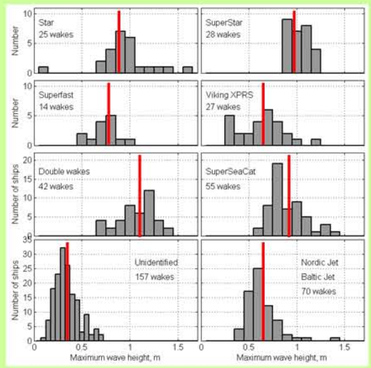
Original water surface elevation record



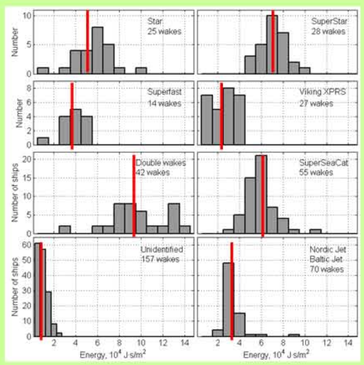
Group structure of a typical fast ferry wake

Vessel	Type	Constr-uction	Cruise speed, knots	Length / Width / Draught, m	Dis-place-ment, t
SuperSeaCat	High-speed craft	Monohull	35	100.3/17.1/2.6	900
Nordic Jet Baltic Jet		Catamaran	36	60/16.5/2.22	515
Star	High-powered con-ventional ships	Monohull	27.5	186.1/27.7/6.75	13 316
SuperStar		Monohull	27.5	176.9/27.6/7.1	14 073
Viking XPRS		Monohull	25	185/27.7/6.55	14 165
Superfast		Monohull	25.5	203.3/25/6.5	10 703

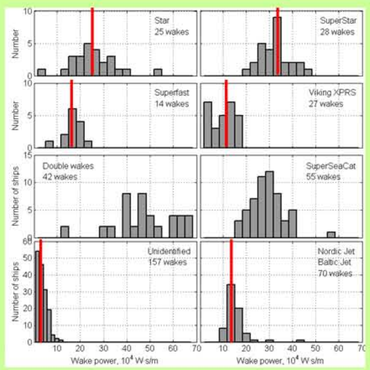
RESULTS



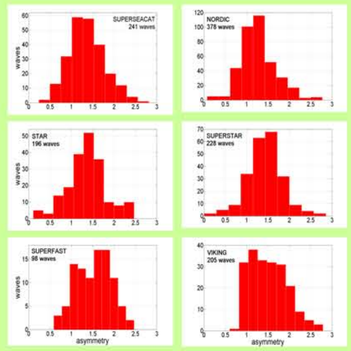
Frequency of occurrence of maximum wave heights in wakes from different ships



Frequency of occurrence of total energy in wakes from different ships



Frequency of occurrence of total wave power in wakes from different ships



Asymmetry of waves in the first group for different ships

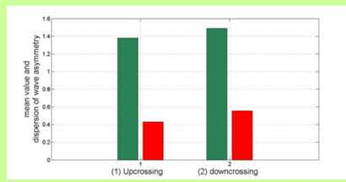
Average value and dispersion of asymmetry coefficient

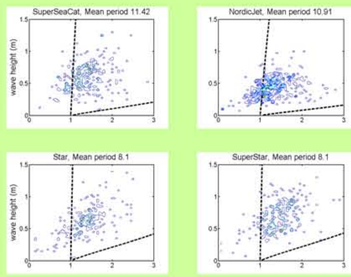
It suggests that ship waves, by nature, are more similar to **regular waves** than to freak waves

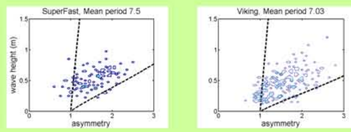
$$\frac{A_+}{A_-} = \frac{m}{m + E/K - 1} - 1 \qquad \frac{H}{h}\frac{gT^2}{h} = \frac{16}{3} m K^2(m)$$

$$K(m) = \int_0^{\pi/2} \frac{du}{\sqrt{1 - m\sin^2(u)}} \qquad E(m) = \int_0^{\pi/2} \sqrt{1 - m\sin^2(u)}\, du$$

A+ and A- are maximum and minimum amplitudes of positive and negative semi-waves;
K and E are complete elliptic integrals of first and second kind; H is a wave height, h is a water depth; T is a wave period; g is a gravity acceleration







CONCLUSIONS

* The largest **ship wave** heights were **1.5 m**, the combined **ship and wind wave** heights reached **1.7 m**
* The **largest waves** and maximum wake energy are usually produced by **Star** and **Superstar (strongly powered, but otherwise conventional ferries)**
* The **average asymmetry coefficient** for ship waves is approximately **1.4**
* This suggests that ship waves are more similar to **regular waves** than to freak waves
* A **nonlinear** (e.g. **cnoidal) wave** theory should be used to describe waves from fast ferries
* The **maximum wave height** is an **appropriate parameter** to characterize the ship wakes and their variability