THE RELATIVE IMPORTANCE OF WIND-WAVES AND SHIP-WAKES ON LONGSHORE DRIFT IN TALLINN BAY, THE BALTIC SEA

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Energy budget: the role of ship wakes

- In low to medium energy coastal environments, ship wake-wakes can be quantitatively distinguished with respect to wave height, period, energy and flux;

- All vessels add to the overall energy but High-Speed Craft (HSC) wake-waves:
  - Can have a much longer period and height (and therefore energy) than natural waves;
  - Can cause increased mobilization of seabed sediments;
  - Are potentially dangerous for people on the shore or in small boats;
  - May damage structures at the shore, or moored vessels;
  - May increase erosion of the shoreline;

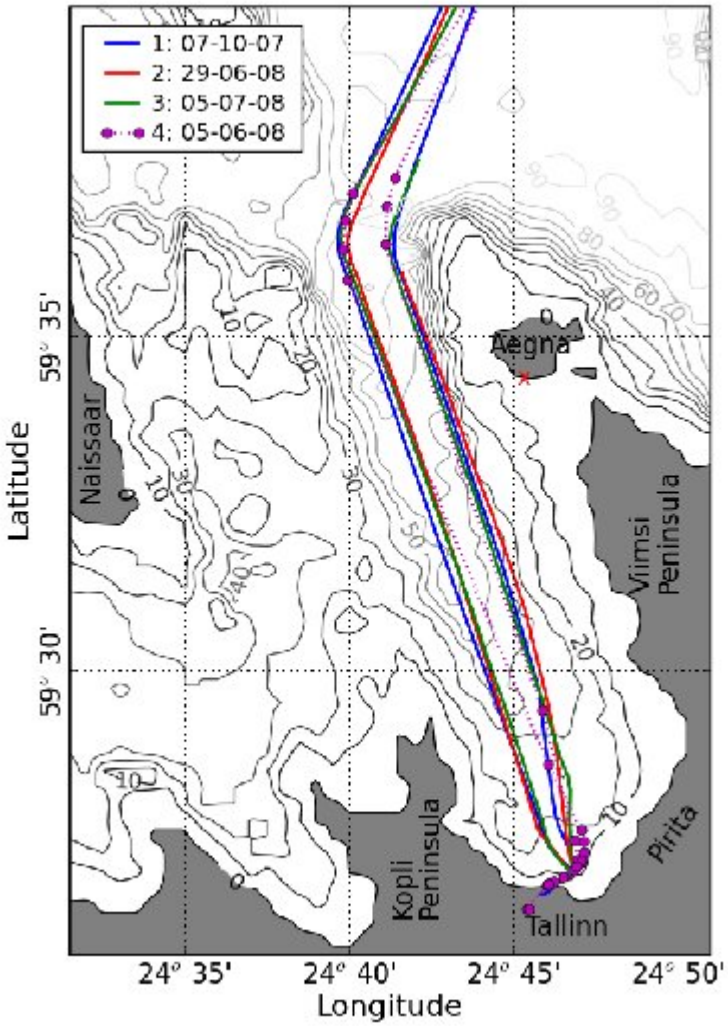
- The highest energy is contained in the solitonic-like waves that form the leading and first group of HSC wakes.

Aims

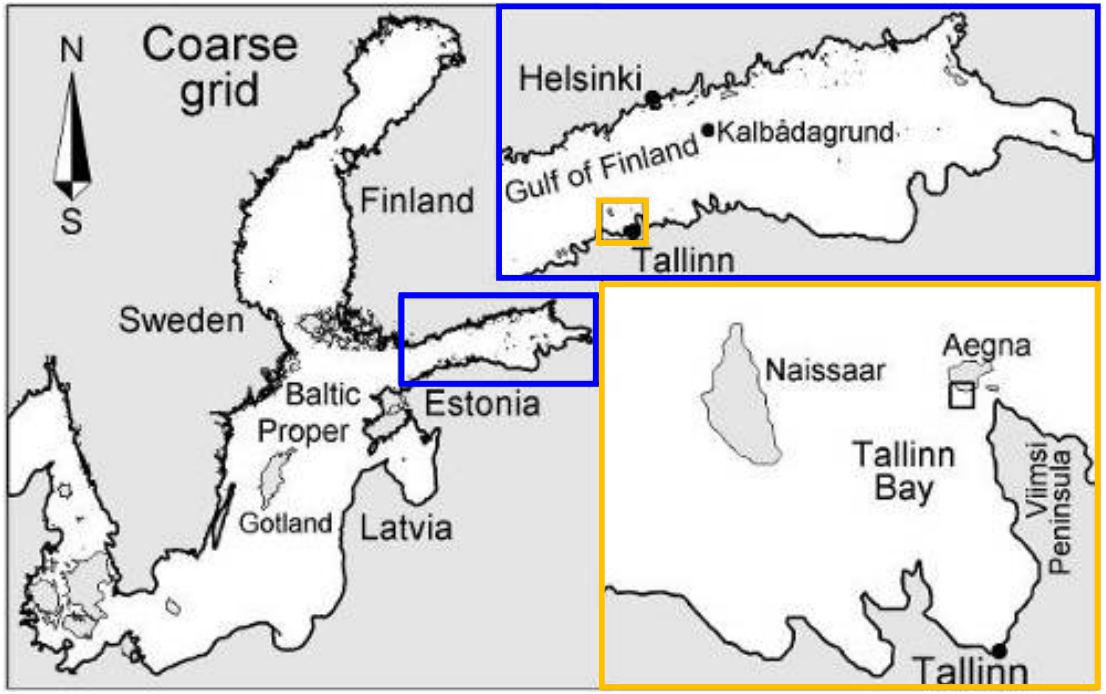
- Estimate the role of vessel wakes in the overall wave activity for a section of medium-energy coast, based on an experiment undertaken in June–July 2008;
- Compare daily maximum ship-generated wave heights with extreme natural waves in this area;
- Determine the contribution of ship-generated wave energy and flux to total wave energy;
- Quantify the role of ship-generated waves on the longshore sediment transport.

Study area


66° N
62° N
58° N
54° N
16° E
20° E
24° E
28° E
Gulf of Bothnia
Sweden
Finland
Sea
of Bothnia
Helsinki
Gulf of Finland
Almagrundet
Tallinn
Estonia
Russia
Vilsandi
Baltic
Proper
Latvia
Lithuania
Russia
Poland

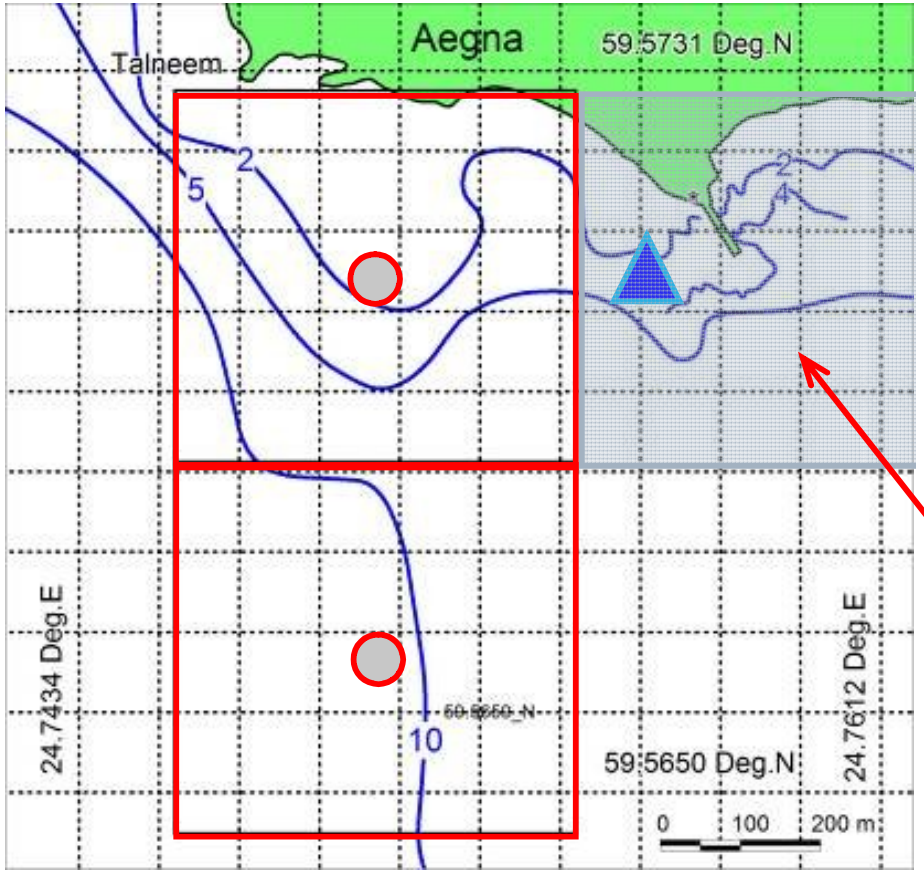

1: 07-10-07
2: 29-06-08
3: 05-07-08
4: 05-06-08
Latitude
59° 35'
59° 30'
24° 35'
24° 40'
24° 45'
24° 50'
Longitude
Aegna
Naissaar
Viimsi
Peninsula
Kopli
Peninsula
Pirita
Tallinn

Wind wave climate



- Triple-nested version of WAM model (Komen *et al*., 1994)
- Model for Gulf of Tallinn: grid step of about ¼ nautical miles;
- Boundary condition from model applied to whole Baltic Sea;
- Model forced with wind data from Kalbådagrund.

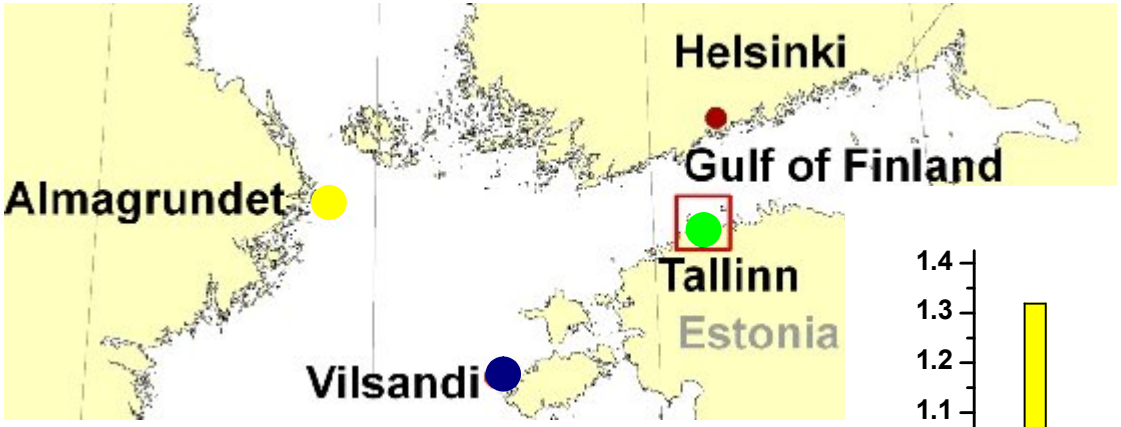
Wind wave climate

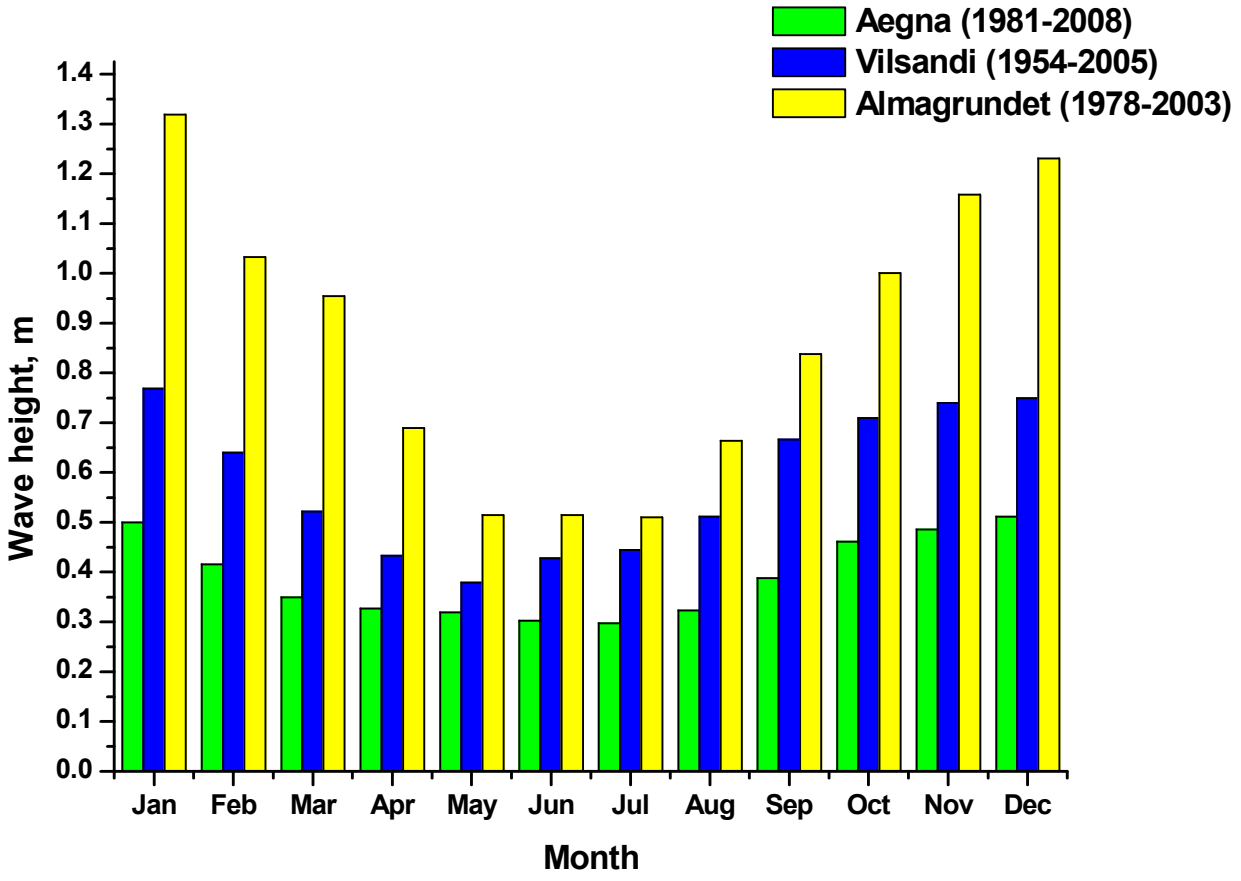


- Wave data for 2m and 7m depths;
- Hs, T and direction:
- The model was run for 1981-2008.

Land in model

Monthly mean wave height at Aegna, Vilsandi, Almagrundet

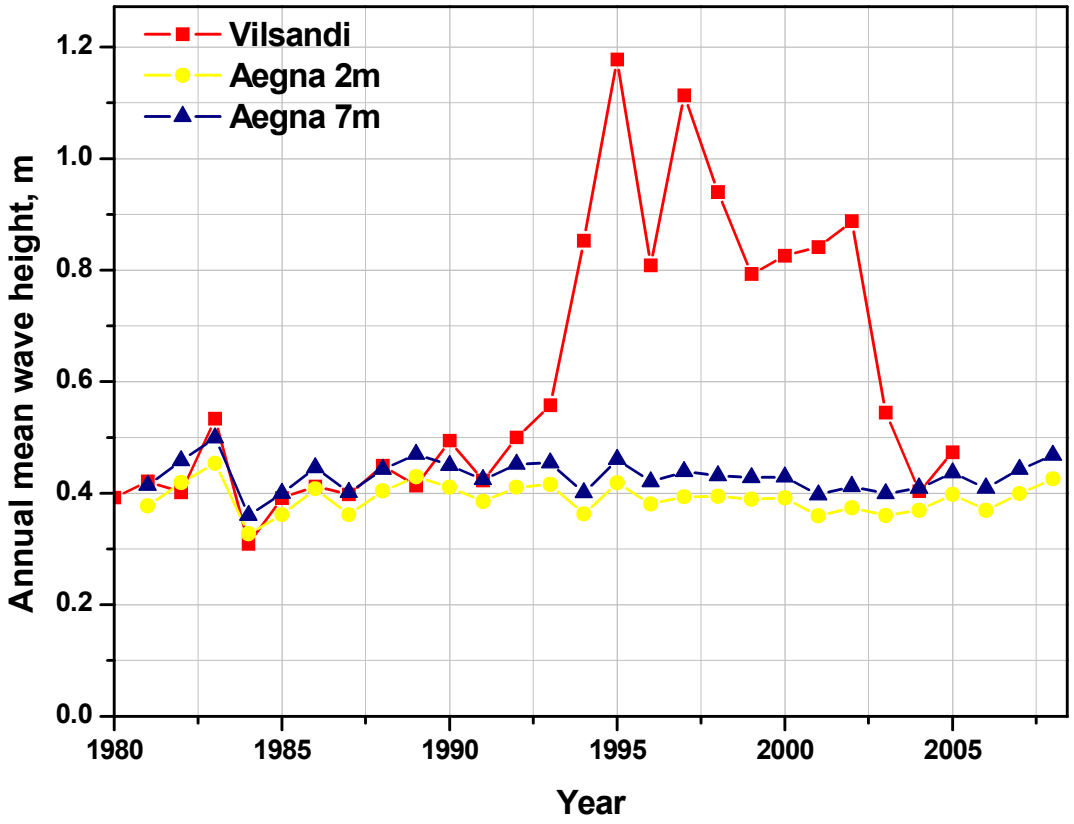




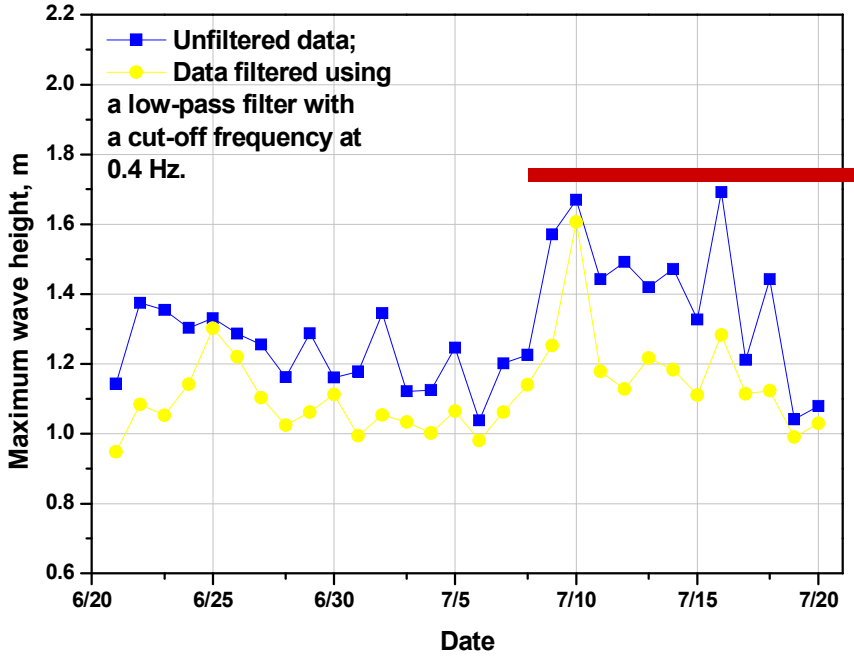
Annual mean visually observed wave heights at Vilsandi and modeled wave height at Aegna

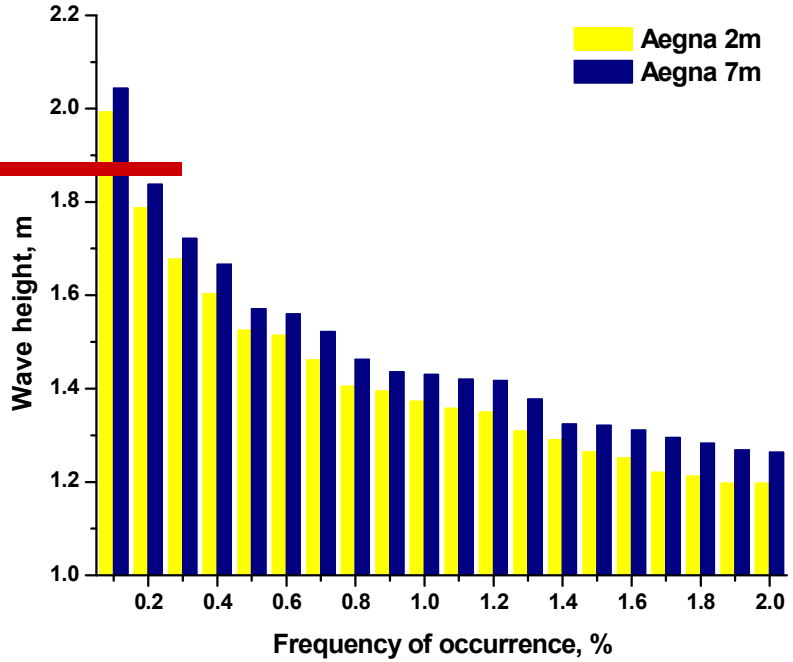
Tallinn Bay open only for NNW, W winds.

Vilsandi open to the S,SW, W,NW winds.



Vessel-wake maximum daily wave heights

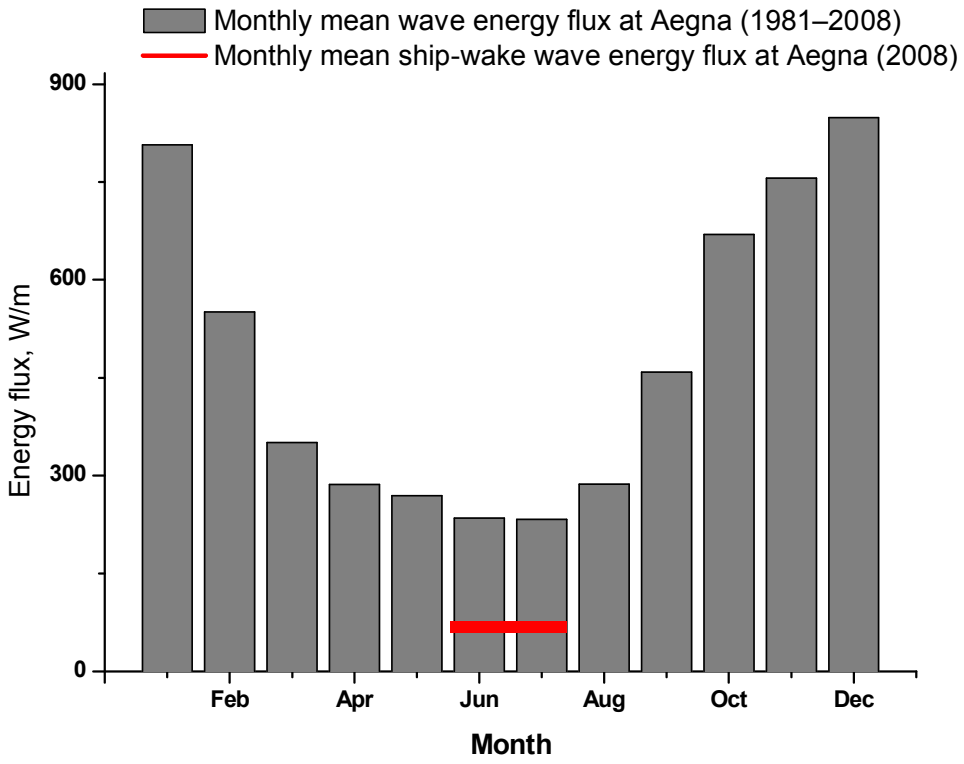




Слайд 9

K18 Much better! What do you think about the line I have put in (maybe have it appear). the point being that the largest wwakes, that happen frequently are equivalent to about the highest 0.4% of natural waves. Maybe you could make it look nicer!
Kevin; 04/01/2009

Wave energy flux at Aegna



- The average value of wind-wave energy flux over 1981–2008 at a depth of 2.7 m was 480 W/m;
- The average vessel-wake energy flux was estimated to be about 70 W/m;
- Vessel wakes contribute about 15% of the total energy flux and ~25% in relatively calm years.

K20

Слайд 10

K19 This doesn't quite make sense. I am still not sure I would understand why you use energy flux rather than energy. I think the reason is that it is a better indicater of the ability of the wave to do geomorphic work (ie casue erosion, move sediments etc) than energy.
Kevin; 04/01/2009

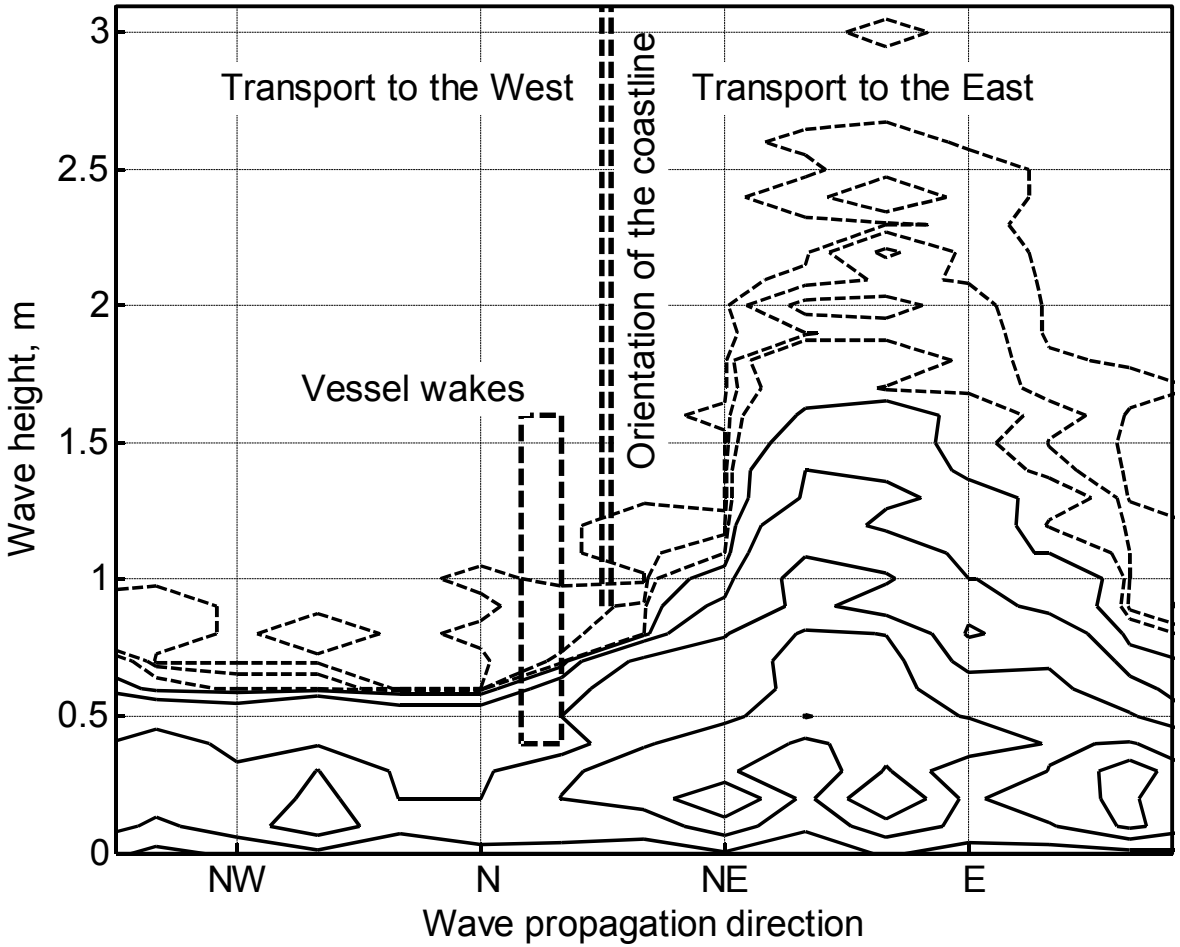
K20 Now I am a bit confused. Are these numbers the average of the daily maximums, over these two months. Maybe check this with Tarmo to see if we are comparing like with like.
Kevin; 04/01/2009

Longshore transport

Energy flux (CERC) model

$$Q_l = K \frac{Ec_g \sin\alpha_b \cos\alpha_b}{(\rho_s - \rho)g(1-p)}$$

Modelled significant wave heights and propagation directions



d_{50}=5 (mm)	Wind	Vessel
	1000 m³/year	
Bulk	879	222
Net	−736	222
%	−84%	100%

Isolines for 1, 3, 10, 33, 100, 330, 660, and 1000 cases, in the nearshore of the SW coast of Aegna.

CONCLUSIONS

- Vessel wakes contribute significantly to the energy budget of this shoreline, and potentially to many other medium-energy and low-energy shorelines;
- Ship wakes may have extremely strong impact on almost equilibrium beaches;
- The magnitude of this impact depends on the wave approach direction;
- The approach angle of vessel wakes was considerably smaller than that of the largest wind waves and thus the relative impact of ship wakes is comparatively small at SW coast of Aegna;
- Ship wave activity may play an important role in the stability of many types of soft coastal engineering structures (such as beach renourishment) or artificial islands.