

Depth attenuated exposure model

The attenuation of wave energy with depth was modelled to define wave exposure at seabed (Bekkby *et al.* 2008). Depth attenuated exposure was based on Isaeus (2004) simplified surface wave model (SWM) that has been applied in many Nordic countries. Although wave activity changes spatially and temporally, this approach of wave exposure defines the long-term “wave climate” that varies geographically but remains stable over time. Depth dependency for deep-water waves, for which the wavelength is smaller than two times the ocean depth can be formed to:

$$h(z) = h(0) * \exp(k * z),$$

where the wave number k is related to the wave angular frequency w via the dispersion relationship: $k = w^2/g$, where g is acceleration due gravity. Knowledge of the dominant wave frequency and corresponding wave number at a given location in the ocean thus estimates the decay of wave exposure with depth.

Depth attenuated wave exposure model was calculated with expression:

$$\text{SWM}(z) = \text{SWM}(0) * \exp(k_p * z),$$

with equation:

$$k_p = 22^2 * (1/\text{SWM}(0))^{2/3} * g^{1/3},$$

where $\text{SWM}(0)$ is surface exposure, g is acceleration due gravity and z is depth.

Depth exposure model was formed from two different exposure models, one with coarser resolution and the other with finer resolution. Extent of these layers was different, and layers were combined to one surface exposure. Classification of calculated exposure values was based on Rinde *et al.* (2006) documentation of marine nature type models (Table 1). Final exposure model and exposure example areas are provided at Figures 1 & 2.

Table 1. Exposure classes

Exposure classes	Exposure values
Extremely sheltered	< 1200
Moderately sheltered	1200 – 4000
Relatively sheltered	4000 – 10000
Sheltered	10000 – 100000
Relatively exposed	100000 – 500000
Moderately exposed	500000 – 1000000
Exposed	1000000 – 2000000

Depth attenuated wave exposure model

Exposure classes

- Extremely sheltered
- Moderately sheltered
- Relatively sheltered
- Sheltered
- Relatively exposed
- Moderately exposed
- Exposed

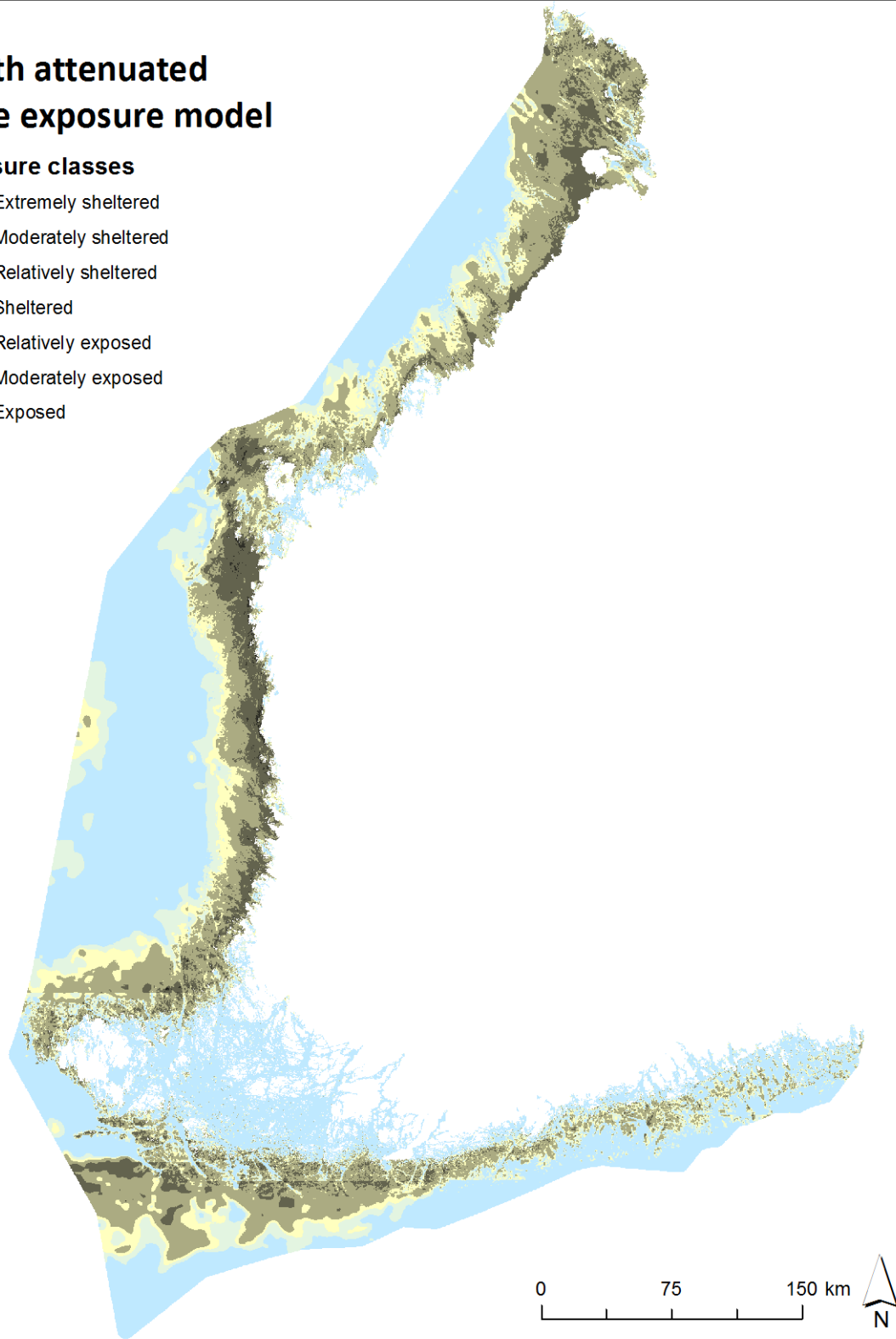









Figure 1. Depth attenuated wave exposure model calculated for the whole EEZ-area of Finland.

Example areas of depth attenuated wave exposure values

Exposure classes

	Extremely sheltered
	Moderately sheltered
	Relatively sheltered
	Sheltered
	Relatively exposed
	Moderately exposed
	Exposed

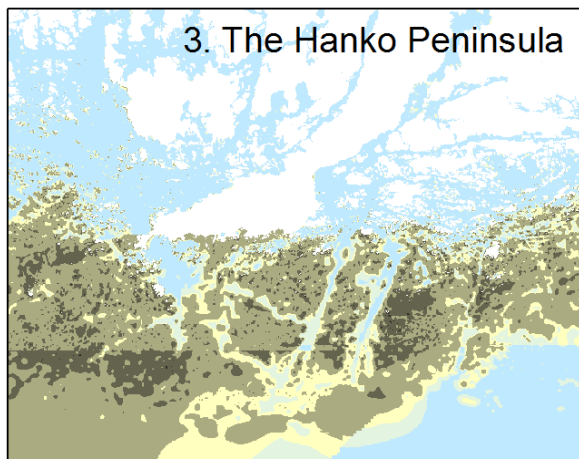
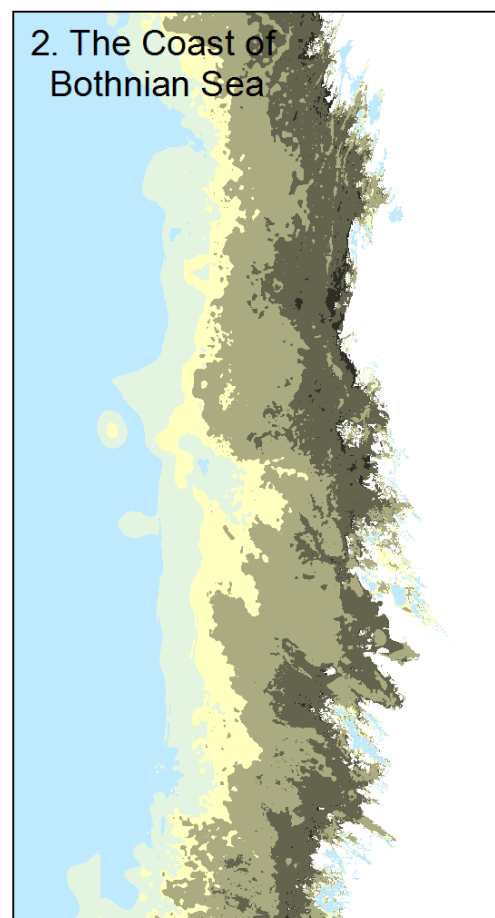
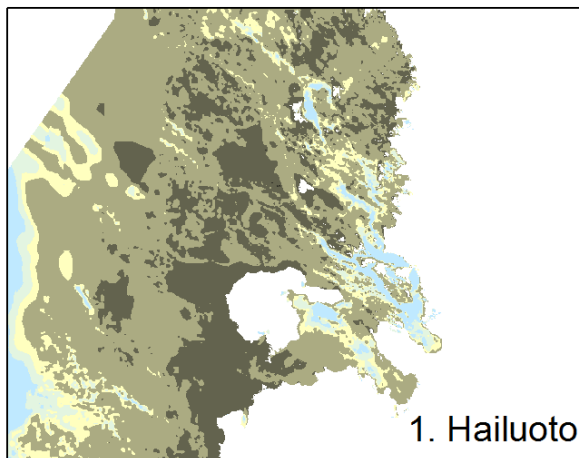
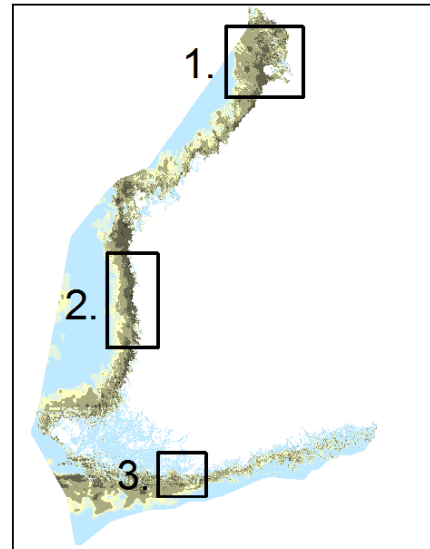


Figure 2. Example areas of depth attenuated exposure: Hailuoto, The Coast of Bothnian Sea and the Hanko Peninsula. Darker colors indicate higher exposure and lighter sheltered areas.

References:

- Bekkby, T., P. E. Isachsen, M. Isaeus & V. Bakkestuen (2008). GIS Modeling of Wave Exposure at the Seabed: A Depth-attenuated Wave Exposure Model. *Marine Geodesy*, 31: 117–127.
- Isaeus, M. (2004). Factors structuring Fucus communities at open and complex coastlines in the Baltic Sea. Doctoral thesis, Department of Botany, Stockholm University, Sweden. <http://www.aquabiota.se/publications/pdf/Avhandling_Isaeus.pdf>
- Rinde, E., B. Rygg, T. Bekkby, M. Isaeus, L. Erikstad, S.-E. Storeid, & O. Longva (2006). Documentation of marine nature type models included in Directorate of Nature Management's database Naturbase. First generation models for the municipalities mapping of marine biodiversity. NIVA Report LNR 5321-2006.