On Defining Wave Energy Pilot Sites in Swedish Seawaters

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Abstract – This paper introduces a recently started national Swedish project funded by the Swedish Energy Agency to map conditions of relevance for the prospects of establishing and operating offshore wave energy devices in Swedish seawaters, including the Swedish Exclusive Economic Zone (EEZ). The mapping will cover geological, meteorological and oceanographic variables in high resolution, including wave climate, conditions on the seabed, sea-ice conditions, sea-level fluctuations and how surface currents influence drifting sea-ice. Mapping will also include ecosystem components, maritime activities and regulated areas. Furthermore, the project will predict power production for the purpose of locating suitable pilot sites for offshore wave energy conversion and to identify favourable zones for establishing and operating future large scale installations from the point of view of the physical conditions. This paper presents methodology and initial results for high-resolution wave modelling, mapping of geological conditions and ecosystem components for a selected focus area outside the Swedish east coast in the Baltic Sea. The paper also presents methodology for modelling predicted power production with a generic point absorber type wave energy converter technology.

Studied area (SWE-EEZ)

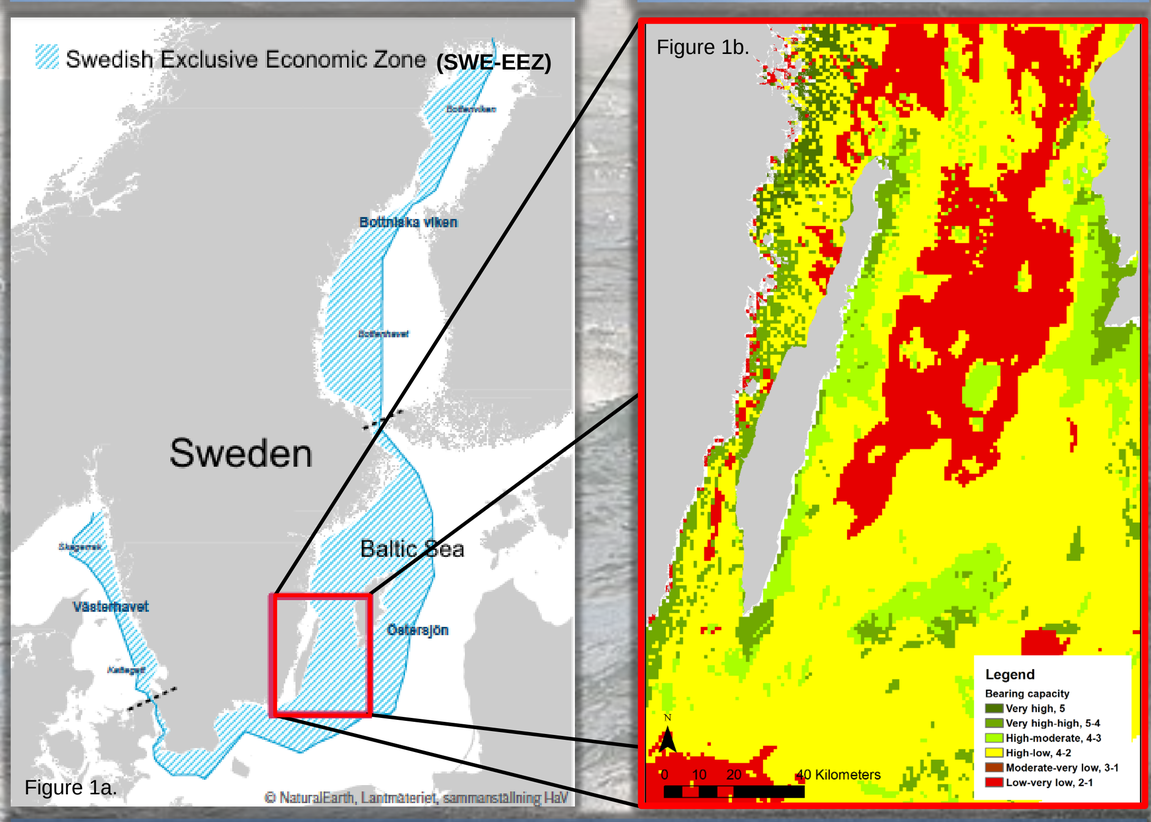

Figure 1a-b. (a) The studied area indicated in blue is the Swedish offshore EEZ. The focus area for this paper is indicated by a red frame. (b) Example of seabed geology in focus area. The bearing capacity of the upper meter of the seabed is divided into five different levels, derived from marine geological information and terminology. Project grid resolution: 1 x 1 km.

Wave climate modelling

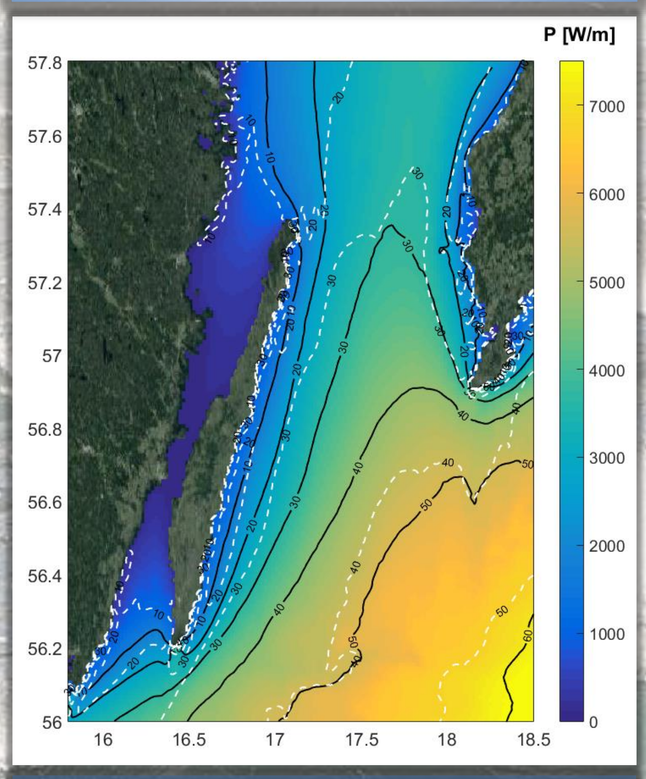

Figure 2. Wave energy per m wave front in colour for ice-free conditions in the focus area (fig. 1b). Black isolines (from 10 to 60) indicate mean number of days per year with significant wave height above 2 m. White dashed isolines indicate mean number of days per year with energy periods above 6 seconds.

Sea ice interference

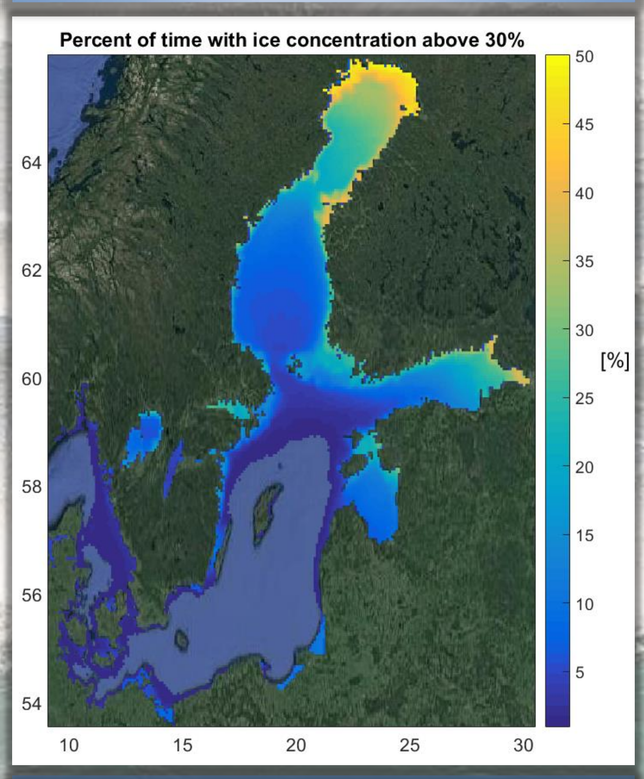

Figure 3. Percent of time with ice fraction above 0.3 based on 35 years of ice data from 1980 to 2014 interpolated using the same method as used by the WAM model. [Hasselmann *et al.* (1988), "The WAM Model – a third generation ocean wave prediction model", *J. Phys. Oceanogr.*, 18(12), pp 1775-1810].

Predicting power production by modelling of generic point absorber WEC farms

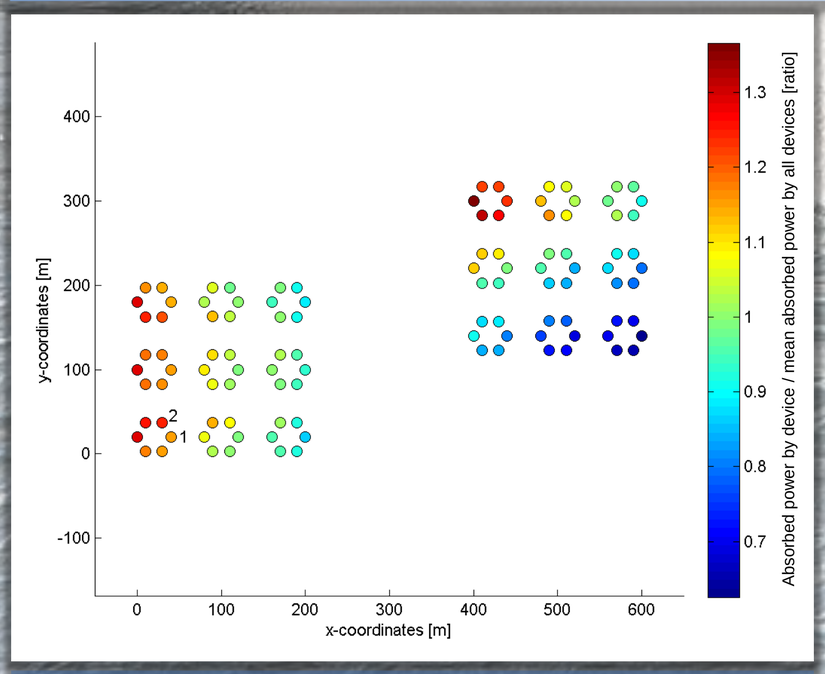

Figure 4. Simulation of two clusters of WECs show that the clusters experience destructive hydrodynamic interaction due to scattered and radiated waves. The colour for each WEC shows the ratio between the power absorbed by the device and the mean power absorbed by all devices in the farm. The waves are propagating from left to right.

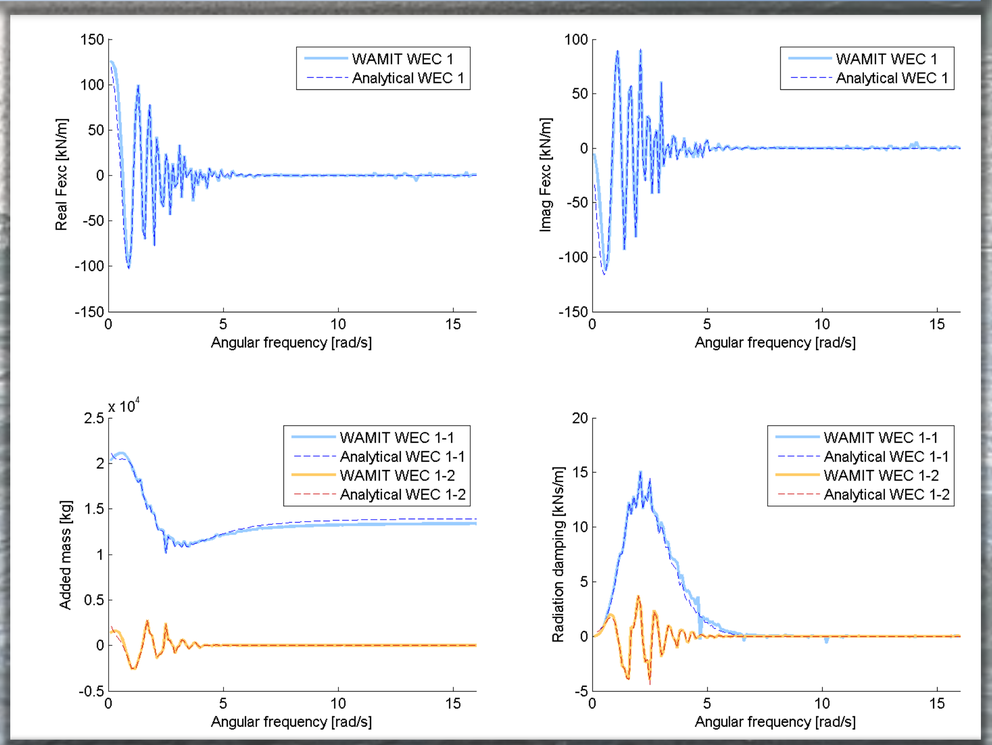

Figure 5. Hydrodynamic forces computed from software WAMIT and the analytical method for WEC 1 in fig. 4 in a cluster of 54 WECs. The upper two figures show the real and imaginary parts of the excitation force. The lower two figures show the two parts of the radiation force: the added mass and the radiation damping. The '1-2' notation refers to the non-diagonal entry in the radiation force, i.e. the coupling between radiated waves of WEC 1 and WEC 2 (in fig. 4).

Ecosystem sensitivity

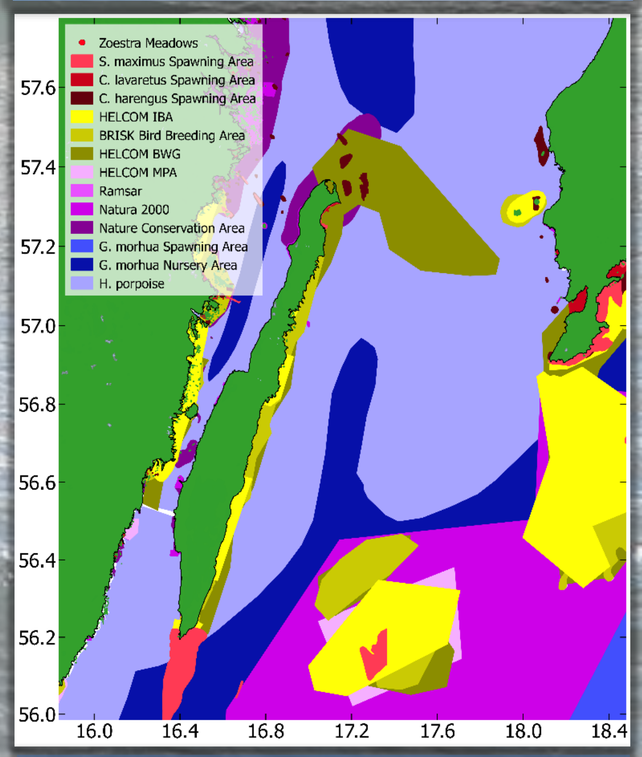

Figure 6. Mapped areas of ecological interest within the focus area in fig. 1b including both ecosystem components and nature conservation areas. Areas of interest are accumulated in the project grid for further evaluation of WEC-farm suitability.

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