ESTIMATION OF THE WAVE ENERGY POTENTIAL ON THE OFFSHORE NORTH-WESTERN MEDITERRANEAN SEA AND PROPAGATION TOWARD NEARSHORE AREAS

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Paper topic: Coastal waves, currents, tides and storm surges

1. Introduction

Currently in the energy sector there is an increasing interest in renewable energy sources and, within this context, the possibilities of producing energy from the waves in the sea is also emerging. The quantification of the availability of such an energy form is the first step to take and constitutes a fundamental element at the base of studies into the practicalities inherent in its conversion to usable forms through the so-called WEC - Wave Energy Converter technologies (Falcão, 2010). On a European level, important contributions have been supplied in this sector such as Pontes et al. (1996), but the Mediterranean has still only received little attention (Cavaleri, 2005, Vicinanza et al., 2011). This study adds to the knowledge of the availability of energy from the Mediterranean Sea. In addition to the analyses concerning the availability of energy from the wave motion offshore in the North-Western Mediterranean Sea, a procedure has been developed based on a numerical simulation for the detailed analysis of coastal areas with a serviceable depth of less than 100m which can be useful in the identification of eventual focus zones.

2. Objective

In this work an estimation of the availability of the wave power in the North-Western Mediterranean Sea and a propagation to coast in three selected areas were carried out.

3. Methodology

The analyses of this paper are based on wave data arising from numerical simulation models for wave generation coupled with atmospheric models. The wave data were provided by IFREMER (French Research Institute for Exploration of the Sea) that has developed a pre-operational system, called PREVIMER, aiming to provide short-term forecasts (0 – 6 days) concerning the coastal environment along the French coastlines bordering the English Channel, the Atlantic Ocean and the Mediterranean Sea. The PREVIMER wave forecasts is calculated by SHOM using the WaveWatch III (WW3) numerical code, with a third-order accuracy propagation scheme in space and time, forced by ECMWF meteorological data for large scale, provided by Météo-France. The model results are provided in the NetCDF format at 3 hour intervals and the variables are, for example, significant wave height, wave energy period, mean wave direction. The WW3 PREVIMER model that covers the NW Mediterranean Sea, from 1° W to 11° E of longitude and from 40° N to 45° N of latitude, with a resolution of 4 km, is called, until the 24 November 2010, MENOR-4000M, and after the 25 November 2010, MENOR-2MIN. The analyzed data-set covers a period of 2 years and 9 months, from 2 July 2009 to 31 March 2012.

The formula used to compute the monthly and yearly mean wave power, in the case of irregular waves propagating in deep waters, is reported in eq. (1).

$$P = \frac{1}{64}\frac{g^2}{\pi}\rho H_{mo}^2 T_{m-1,0} \tag{1}$$

with ρ water density and providing that $H_{m0}=4m_0^{1/2}$ is the significant wave and $T_{m-1,0}=m_{-1}/m_0$ is the

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mean spectral wave period or energetic period.

Although the offshore wave energy potential is known from the offshore analysis, the processes affecting the waves as they propagate towards the nearshore can modify the wave energy potential, leading to reductions or, sometimes, local enhancements due to focusing mechanisms. To quantify these processes, and then select the most energetic locations, numerical simulations were performed to propagate the power time series from deepwater into the nearshore area of the selected test sites.

The numerical simulations were carried out by MIKE 21-Spectral Wave (MIKE 21 SW) of the DHI Institute. The SW is a third generation spectral wind-wave model based on unstructured mesh that allows the simulation of the following physical phenomena: non-linear wave-wave interaction, dissipation due to white-capping, dissipation due to bottom friction, dissipation due to depth-induced wave breaking, refraction and shoaling due to depth variations.

The model is used with the fully spectral formulation, based on the wave action conservation equation, where the directional-frequency wave action spectrum is the dependent variable and with the quasi-stationary mode, where the time is removed as an independent variable and a steady state solution is calculated at each time step.

As offshore boundary conditions the values of wave height, peak period, average direction and spreading factor, of the points extracted by the MENOR-4000M PREVIMER model on a depth of 100m, were used.

This methodology was applied to the stretch of coast between La Spezia and Piombino, in Tuscany, between Monaco and Imperia, in Liguria, and between Stintino and Alghero, in Sardinia.

Acknowledgements

This study constitutes part of the program of the Research Doctorate of Engineer V. Vannucchi, in Civil and Environmental Engineering, at the DICeA, University of Florence.

The authors wish to thank: i) IFREMER for the use of data and in particular Dr Fabrice Lecornu; ii) DHI- Italia for having supplied the availability of the software MIKE21, and in particular Engineer Andrea Pedroncini.

The support of the MARINET Project (EU-FP7, www.fp7-marinet.eu), is gratefully acknowledged.

References

Falcão, A., 2010. Wave energy utilization: a review of the technologies. *Renewable and Sustainable Energy Reviews*, 14, pp. 899-918.

Pontes, M.T., Athanassoulis, G.A., Barstow, S., Cavaleri, L., Holmes, B., Mollison, D. and Oliveira Pires, H., 1996. WERATLAS - Atlas of Wave Energy Resource in Europe. *Technical Report*, DGXII Contract No. JOU2-CT93-0390, INETI, Lisbon.

Cavaleri, L., 2005. The wind and wave atlas of the Mediterranean Sea – the calibration phase. *Advances in Geosciences*, 2, pp. 255–257.

Vicinanza, D., Cappietti, L., Ferrante, V. and Contestabile, P., 2011. Estimation of the wave energy in the Italian offshore. *Journal of Coastal Research*, SI 64 (*Proceedings of the 11th International Coastal Symposium*), Szczecin, Poland, ISSN 0749-0208, pp. 613-617.