Return periods for Extreme Waves in the Atlantic Offshore of Ireland

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Project Aim

To characterise the extreme wave climate off the west coast of Ireland in order to inform offshore engineers and designers of offshore facilities in the oil, gas and renewables sectors.

Data sources

There are several wave buoys moored off the Irish coast (Fig.1). Historically, buoys only reported summary data, typically the significant wave height H_s, the mean height of the highest $^1/_3$ of peaks during a half-hour interval. However, high-frequency (*c*. 1 Hz) measurements of the ocean free surface elevation are required in order to fully characterise the wave climate, and in particular, the maximum wave height H_{max}, needed to assess the incidence of extreme waves.

The only long-term high frequency wave record in Irish waters is from the Datawell buoy at the Atlantic Marine Energy Test Site (**AMETS**), off Co. Mayo. Extensive pre-processing and filtering was required to remove spurious data due to known data quality issues with the Datawell buoy.

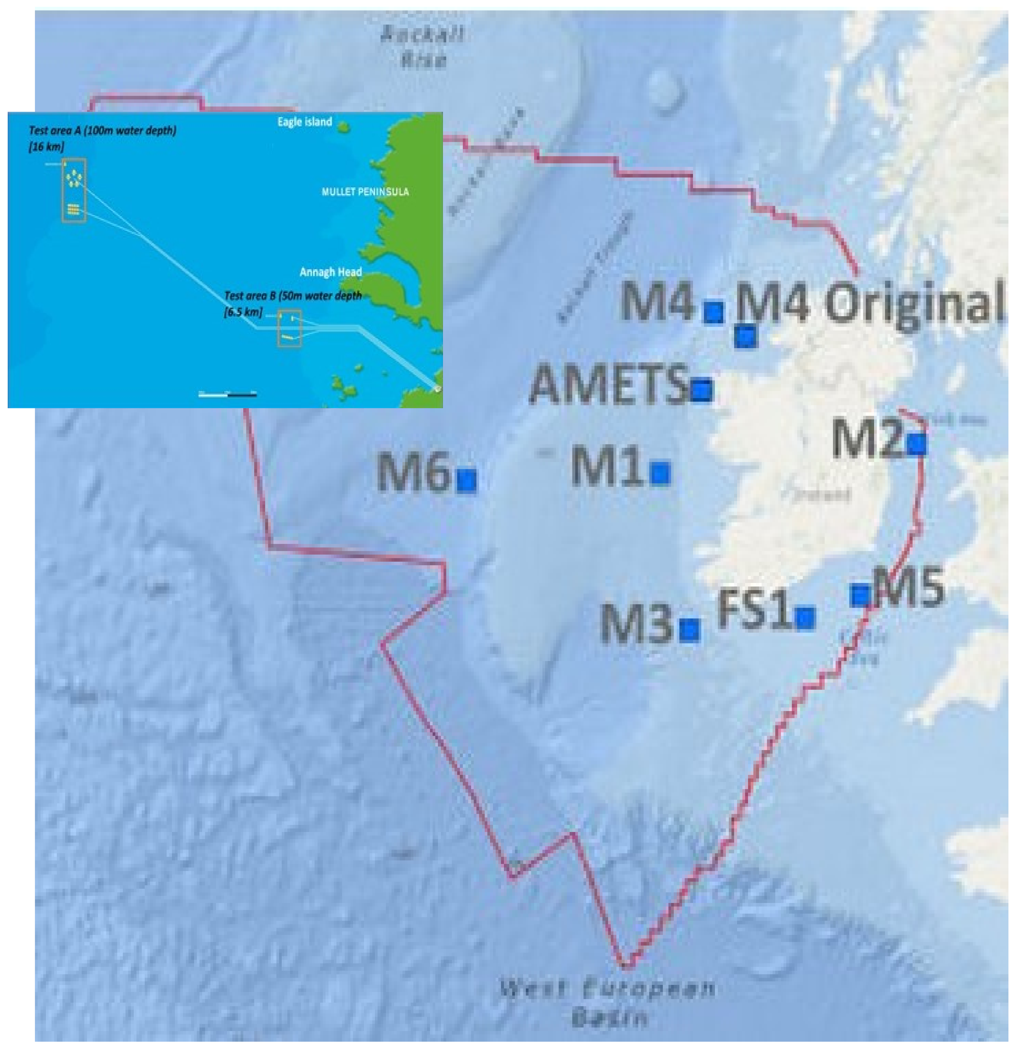

Figure 1. *Irish territorial waters with inset close-up view of the AMETS site*

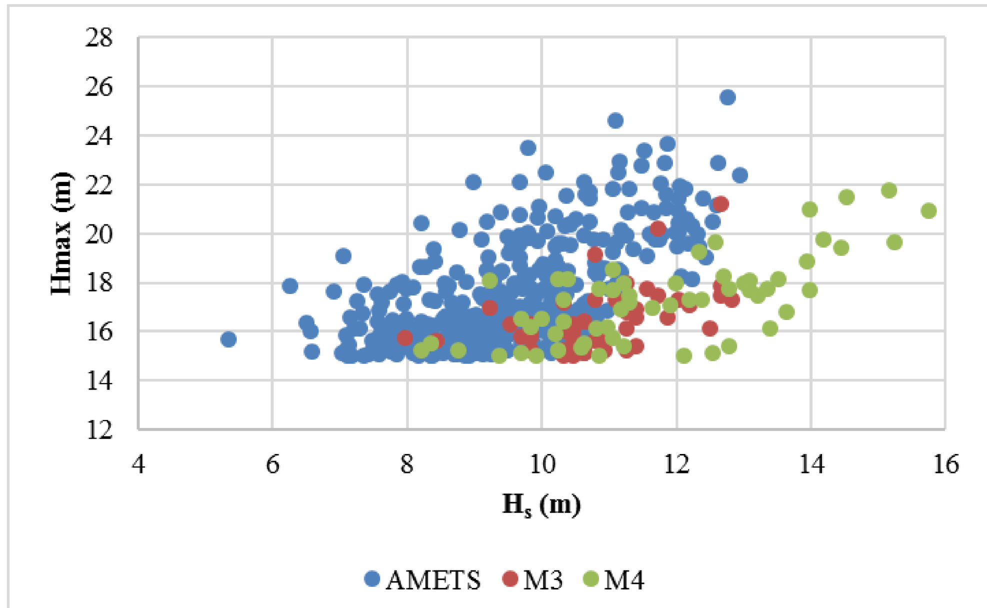

Figure 2. *Scatter plot of H_{max} versus H_s for the AMETS, M3 and M4 buoy records.*

Time domain & spectral analysis

The modal wave periods T_m and amplitudes were determined by using a zero up-crossing analysis of the filtered and quality-controlled record from the Belmullet AMETS site. A Bretschneider spectrum $G_\eta(\omega)$ was fitted to each observed storm sea state:

- this distribution has the advantage that it can be fully specified with just the modal wave frequency ($\omega_m = 2\pi/T_m$) and the significant wave height ($H_s = H_{1/3}$).

$$G_\eta(\omega) = \frac{5}{16}\frac{\omega_m^4}{\omega^5}H_{1/3}^2 \exp\left(-\frac{5\omega_m^4}{4\omega^4}\right)$$

Wave simulation & tank generation

An irregular sea state wave synthesis program was then used to generate long time series conforming to the observed spectral distribution at AMETS. The zero up-crossing code was used to confirm the spectral characteristics matched the observed buoy records. Validation was also carried out for wave tank test data from the National Ocean Test Facility at 1/50 scale.

This approach can then be used to estimate H_{max} for any location for which H_s is known.

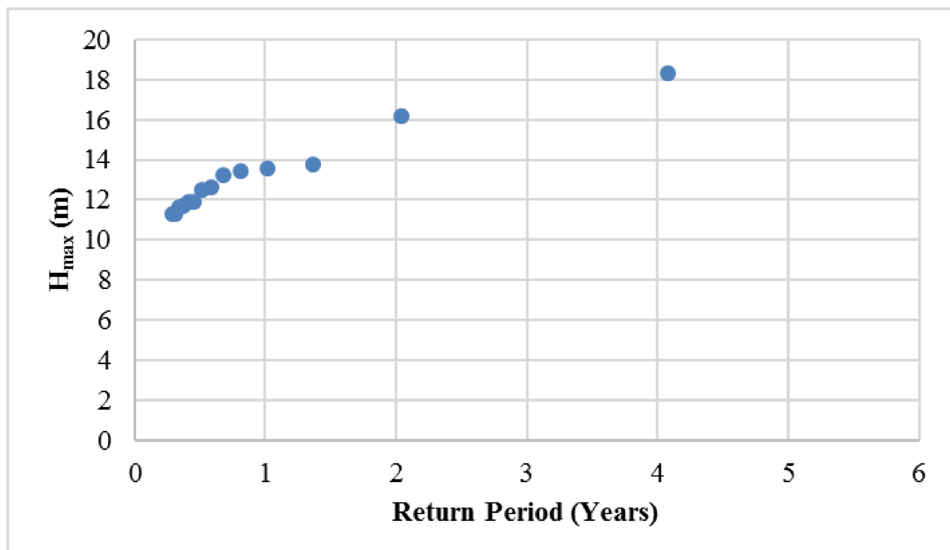

Figure 3. *Empirical probability plot of H_{max} versus return period for the K3 buoy record, showing 18 m wave event with a return period of c. 4 years.*

Figure 4. *View of one of the wave test tanks at the National Ocean Test Facility, University College Cork.*

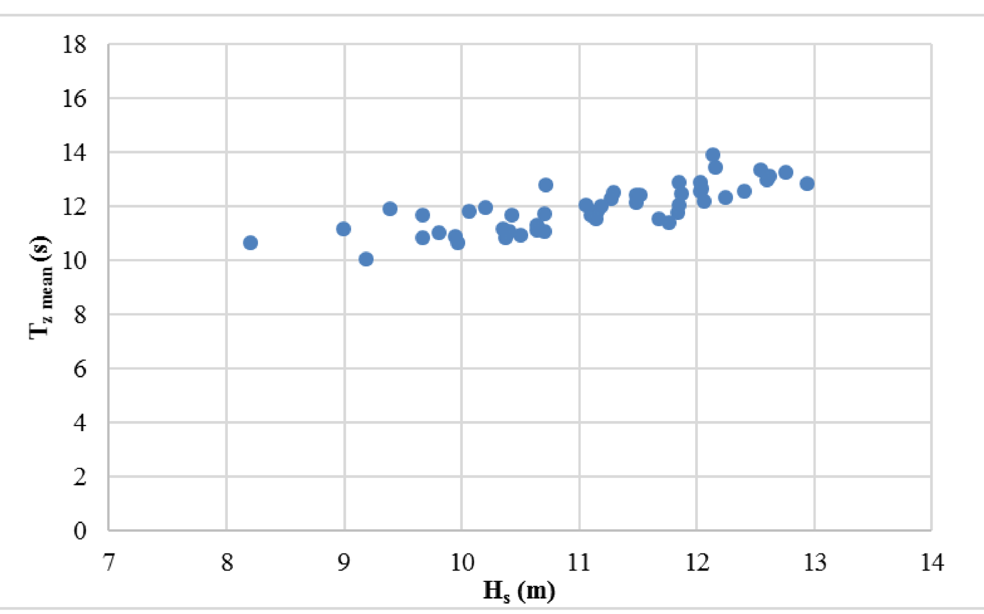

Figure 5. *Relationship of zero-crossing period T_z and significant wave height H_s for 50 largest recorded events at AMETS*

Key Results

- A methodology has been validated to allow for extreme wave (H_{max}) estimation at any location for which a H_s record exists.
- The largest observed events in the records studied occurred at the K3 buoy (>18 m; return period c. 4 years) and at AMETS (> **21 m**; return period c. **4 years**).
- These are enormous wave heights with quite short return periods, therefore should be accounted for in offshore platform design.

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