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A modelling approach for Offshore Wind Farm Feasibility with respect to Ecosystem-based Marine Spatial Planning	[1]Kemal Pınarbaşı; [1]Ibon Galparsoro; Daniel Depellegrin; [1]Juan Bald; [2]Germán Pérez-Morán; [1]Ángel Borja.	[1]AZTI [2]Tecnalia [3]National Research Council – Institute of Marine Sciences (CNR-ISMAR)
Project Wave Energy in the Southern Europe (WESE)	[1]Juan Bald, [2]Teresa Simas, [3]Yago Torre Enciso, [3]Dorleta Marina, [4]Patxi Etxaniz, [4]Borja De Miguel, [5]Pablo Cervantes, [5]Pablo Ruiz, [6]Tuula Mäki, [7]José Chambel Leitão.	[1]AZTI [2] WavEC Offshore Renewables [3] Biskay Marine Energy Platform (BiMEP) [4] IDOM Consulting, Engineering and Architecture, S.A.U. [5] Asociación Centro Tecnológico, Naval y del Mar de Cartagena (CTN) [6] AW-Energy Oy Ltd (AWE) [7] HIDROMOD – Modelação em Engenharia, Lda

DESIGN AND OPERATION FUNDAMENTALS OF THE NUMERICAL AND EXPERIMENTAL WAVE FLUME OF THE UNIVERSITY OF THE BASQUE COUNTRY

G.A. Esteban, U. Izquierdo, J.M. Blanco, A. Peña, I. Albaina, I. Bidaguren, A. Aristondo, L. Galera-Calero

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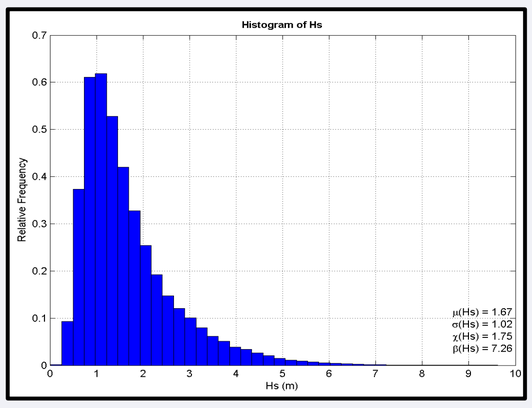
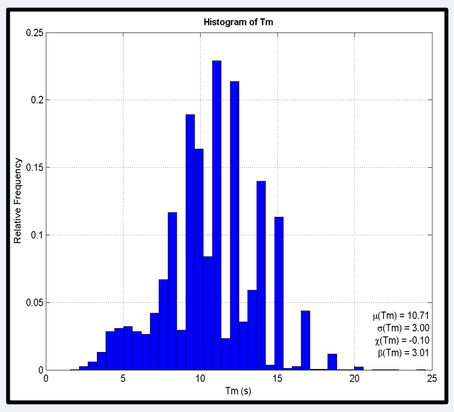
ABSTRACT

Technology and Innovation International platforms for Offshore Ocean and Wind energy identify the use of validated numerical models and small-scale prototypes as a priority area in their corresponding strategic agendas. For that purpose, a 12.5 m long wave flume has been recently deployed in the laboratory of Mechanic Fluids of the UPV/EHU, able to reproduce different wave conditions, including the ones of BiMEP (Armintza), in order to test prototypes of WECs, FOWTs and other devices at laboratory scale. In this work the main characteristics of the facility are presented together with the results of the first experimental campaign, and a CFD model of a numerical wave flume developed as an alternative method to analyze the hydrodynamics of wave-structure interaction.

BIMEP: PROPERTIES OF THE WAVES TO BE REPRODUCED

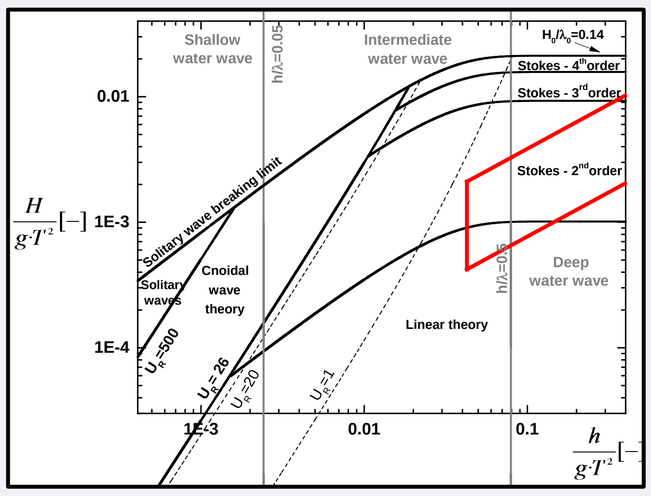
Through a buoy located around the area of BiMEP, data from 1985 to 2015 was collected and processed by the Environmental Hydraulics Institute (IHCantabria). The following results for significant wave height and period were obtained with the software Ameva.





Parameters	Max	Min
H_s (m)	2.5	0.5
T (s)	11.0	5.0
h (m)	-97.4	-50.5

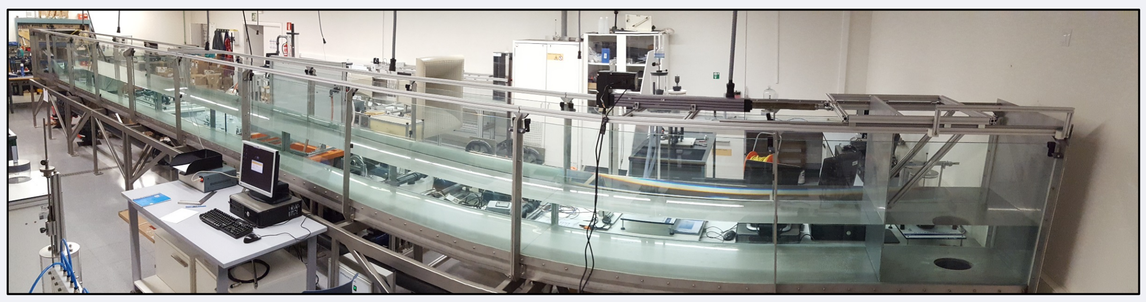
- **Water region** :
  - Intermediate water $\frac{1}{20} < \frac{h}{\lambda} < \frac{1}{2}$
  - Deep water $\frac{h}{\lambda} > \frac{1}{2}$
- **Wave Theory:**
  - Wave Linear Theory
  - Stokes – 2nd order



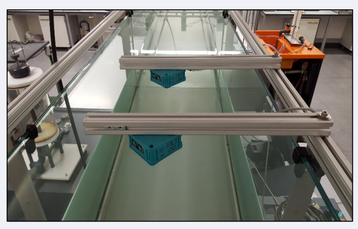
Le Méhauté: The red parallelogram corresponds to the type of waves more frequently measured at BiMEP.

WAVE FLUME

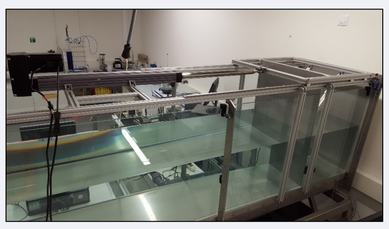
Main dimensions: 12.5 m long, 0.60 m wide and 0.70 m high



Adjustable beach

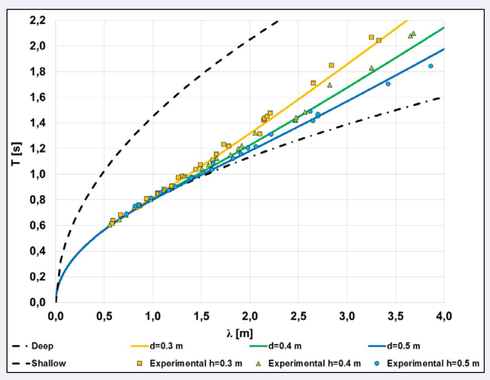


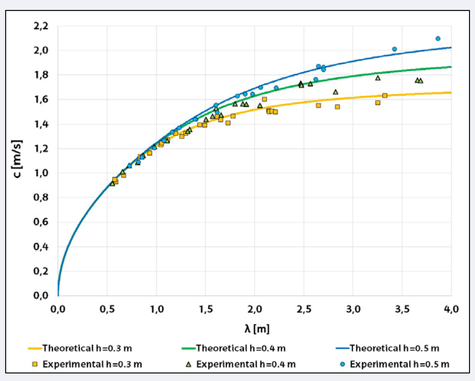
Ultrasonic Wave probes



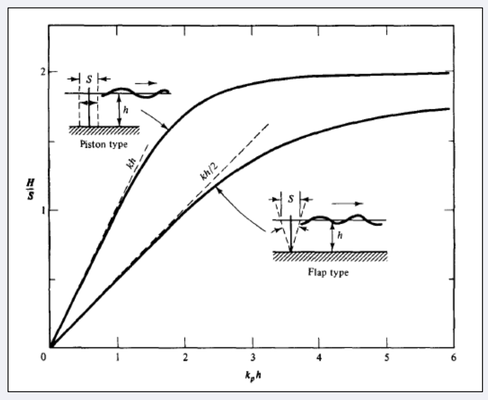
Piston-type wavemaker

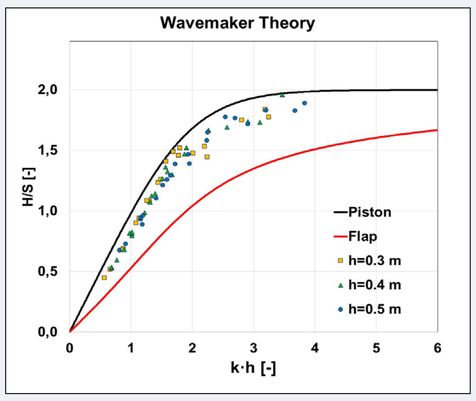
The structure of the flume consist of five modules of 2.5 m long, made of stainless steel. Ten pieces of tempered laminated double glass (2.5 x 0.7 m) define the available working space. Three pumps installed in an underground tank make possible a quick fill and empty of the flume. The extinction zone is an adjustable parabolic beach. The wave generation is carried out by a piston-type wavemaker.





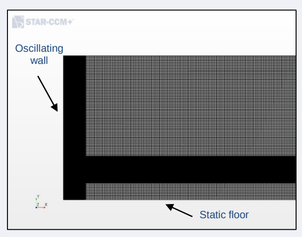
Characterization of wave properties: period, wavelength and velocity of propagation



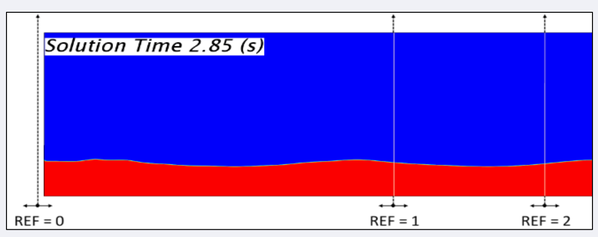


Wavemaker configuration predicting wave characteristics according to theory (Dean and Dalrymple)

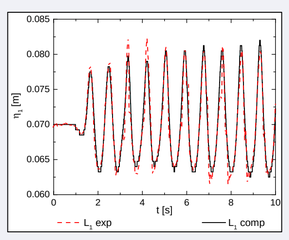
CFD ANALYSIS



Mesh: $6 \cdot 10^5$ cells



Definition of the free surface



Exp. Vs computational

- Oscillating wall, control parameters: stroke amplitude and period
- Eulerian, Volume of Fluid (VOF) unsteady model
- Turbulent k-ε Reynolds Averaged Navier-Stokes (RANS) viscous model
- Surface tensión (0.074 N/m)
- Courant-Friedrichs-Lewy condition, Δt=0.001 s, 5 inner iterations for each time step
- Solver: 2nd order segregated scheme (Rhie & Chow and SIMPLE)

CONCLUSIONS

The wave flume equipped with a piston-type wavemaker, ultrasonic-type wave probes and the corresponding extinction zone is able to simulate a broad range of waves at laboratory scale.

This equipment will be used to analyze and test prototypes of wave energy converters at their initial phases of development, being a useful tool for developers of devices before testing at open-sea.

A computational model has been designed by means of the CFD commercial code STAR-CCM+ for studying the behaviour of the waves generated in a narrow wave flume. The numerical model has been validated through comparisons with the corresponding test results obtained in an experimental wave flume. In addition, the coherence of analytical wave theories with both the experimental and the computational results has been demonstrated.

Acknowledgements: *Authors are deeply grateful to the Basque Government, through projects IT781-13 and IT1314-19*