MEDIOS DE EVALUACIÓN Y ATENUACIÓN DE LOS RIESGOS COSTEROS LOCALES DEBIDOS A IMPACTOS DE LOS TEMPORALES
MaRLiT

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Newsletter

SUMMARY

In March 2022, a two-month campaign of hydrodynamic and sediment transport measurements was carried out on Barceloneta beach, in the city of Barcelona, with the aim of calibrating/validating the numerical models used in the morphodynamic alerts for surrounding beaches within the MARLIT project..

A field campaign for the validation of the morphodynamic alert system in Barcelona

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The effects of storm Gloria in January 2020 and more recently storm Celia (April 2022) along the coast of Catalonia have once again highlighted the need to know in as much detail as possible which is the coastal response to these extreme events, the critical points where the greatest impacts occur and possible mitigation measures.

Currently, oceanographic forecasting systems are a reality. The obtained forecasts in the wave height, period and direction, the next three days, are used by a large number of users, from port or coastal managers to a specialized public. However, warning or prediction systems do not yet incorporate the effect of such conditions on beaches.

To know in advance the response of the coast to a storm is of great importance when defining the most appropriate management strategies to mitigate the possible impacts of a storm. The Interreg POCTEFA MARLIT project, among other objectives, aims to incorporate the impact of wave conditions on beaches in the forecast model chain in what is known as an operational morphodynamic forecast system. In order to reduce the uncertainty of the forecasts its absolutely necessary to calibrate and validate the models in the area of analysis. However, measurements of waves, currents, suspended sediment and topo-bathymetry area rare and many times the models are used with the default parameters.

The calibration and validation of the numerical models that make up the system for the coastal section in which the alerts are to be predicted is essential. However, the difficulty of obtaining both oceanographic and morphodynamic data under high energy conditions means that the default model parameters are used, thus introducing an additional source of error and uncertainty in the predictions.

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The morphodynamic forecast system for the coast of Barcelona

The morphodynamic alert system has been designed as a chain of interconnected models (Figure 1) that are fed by both oceanographic and meteorological forecasts. The COAWST oceanographic model receives the meteorological conditions provided by the ECMWF and the oceanographic variables of waves, mean sea level, temperature and salinity with which it is capable of predicting wave characteristics and mean level, among other parameters, on a very large scale. The COWAST results are used by the XBEACH model that determines the response of the coast in terms of erosion/sedimentation and flooding. The forecast system has been designed to incorporate alert modules for oceanographic variables such as wave height both in open sea conditions and at the foot of the beach, and coastal hazards such as erosion and flooding.

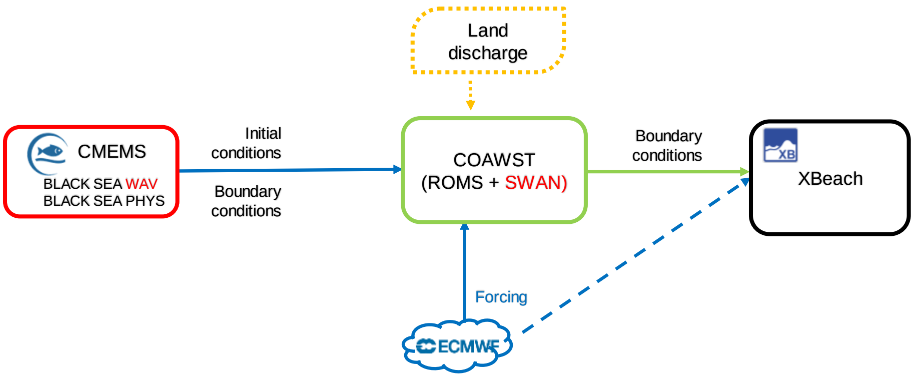

Figure 1. Structure of the operational morphodynamic early warning system for the beaches of the city of Barcelona.

The MARLIT project has carried out a campaign of oceanographic and morphodynamic measurements on the Sant Sebastià beach (Barcelona) lasting approximately two months in which it has been possible to record one of the longest lasting Eastern storms in recent years and the shoreline response under these high-energy conditions. The data obtained during the campaign is being used to calibrate the alert models on this beach and also represents a unique representative set of high-energy conditions in the area.

Field campaign

Figure 2 shows the location of the moorings and the equipment and main characteristics in each of them. The sampling period with data has been from March 9, 2022 to April 27, 2022.

The measurement campaign consisted of obtaining data on waves, currents, sea level and concentration of suspended sediment for a period of approximately 2 months, through the use of autonomous and automatic equipment located at 2 stations located in front of to the Platja de Sant Sebastià in Barcelona. Each deployment is made up of measuring equipment (sensors), a support and protection structure, location and recovery equipment, and a concrete slab (figure 3).

The reinforced concrete slab is 2.2x2.0x0.14 m and its estimated weight in the air is about 1.3Tn. The slab is provided with four fixing elements to facilitate the maneuvers of lowering and lifting it. Once deposited on the bottom, the slab+structure set has a height above it of between 0.8 and 1m.

Código	Localización	Latitud	Longitud	Profundidad
F1	Somera	41°22.454'N	2°11.602'E	8 m
F2	Profunda	41°22.472'N	2°11.712'E	13.4 m

Código	Localización	Composición Fondeo
F1	**Somera**	1 Perfilador Nortek Aquadopp 2MHz (sn AQP1152/ASP6093) 1 Sensor OBS (sn T8280) 1 Estructura de soporte de acero inoxidable 1 Losa de hormigón
F2	**Profunda**	1 Perfilador Nortek Awac 1MHz (sn WAV7845/WPR3466) 1 Sensor OBS (sn T8281) 1 Ancla de liberación/Pinger Teledyne-Benthos 875TD (sn 69871) 1 Estructura de soporte de acero inoxidable 1 Losa de hormigón

Figure 2. Location of the MARLIT campaign moorings at Sant Sebastià beach (Barcelona) during March – April 2022 and main characteristics.

The method used for currents consists in an Acoustic Doppler Effect Profilers (ADCP) with additional wave measurement capacity. The instruments used according to deployments for current and wave measurements are: (i) ADCP acoustic profiler, model AQUADOPP 2MHz and (ii) an AWAC 1MHz AWAC model equipment that provides values of current speed and direction in ten-minute records in layers 0.5m thick, distributed from the bottom to the surface. Additionally, hourly data on wave height and direction are recorded.

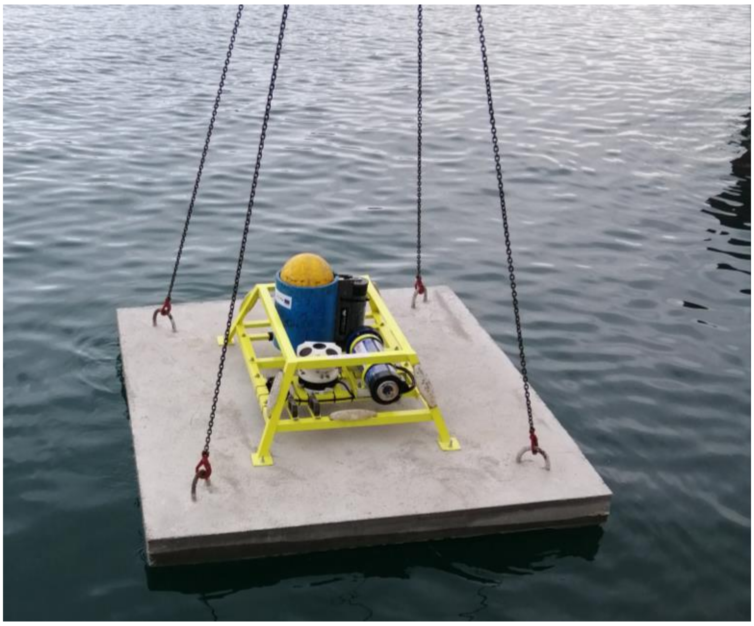

Figure 3. Detail of the anchoring system used.

Turbidity data have been obtained by using OBS3+ model probes (Optical Basckatter Sensor) every 10'. The data obtained can be related to the concentration of the suspended sediment by calibrating the sensor with sediment from the area in which it has been installed.

A bathymetric and topographic survey has been carried out at the beginning and at the end of the campaign using standard equipment for the emerged part and a multi-beam echo sounder for the submerged part (figure 4), as well as taking samples of sediment from the bottom for their later analysis.

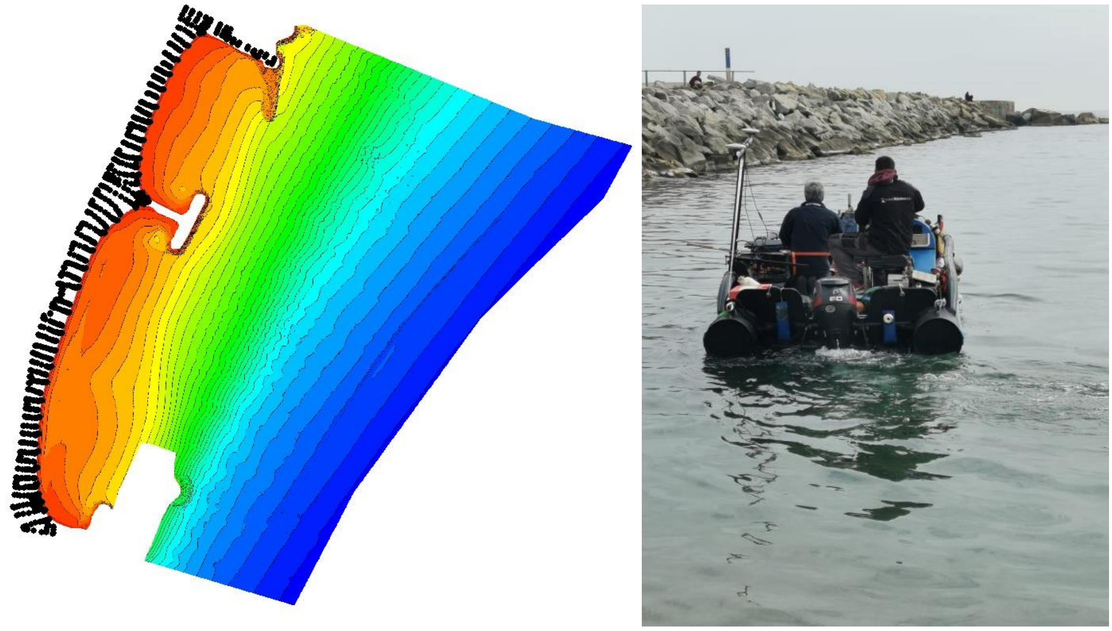

Figure 4. Topo-bathymetric survey and equipment used for the MARLIT March campaign at Sant Sebastià beach.

Oceanographic and morphodynamic measurements during the field campaign

Figure 5 shows the wave conditions recorded at the F2 deployment at a depth of 13.4 m. As can be seen, at the beginning of March there was a storm with wave heights Hs around 2 m and maximums of up to 5 m lasting more than 14 days. The waves maintained a practically constant direction with a clear southerly component. During this long-lasting storm, the period of the waves remained relatively high and constant and of the order of 10 s. It should be noted that in deep water conditions, the Barcelona II wave buoy of the Puertos del Estado oceanographic network recorded a direction of 100º with respect to magnetic north for the same period.

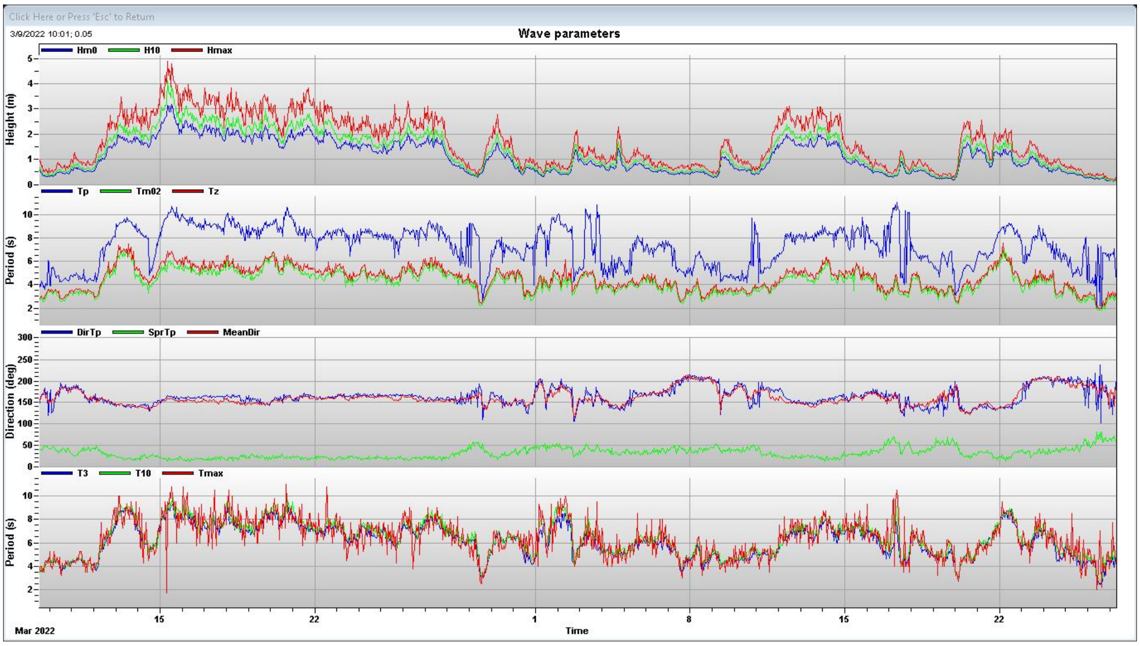

Figure 5. Wave characteristics during the sampling period from March to April 2022 in the MARLIT campaign at Sant Sebastià beach.

This first storm was baptized as the Celia storm and caused severe damage to Sant Sebastià beach and neighboring beaches as shown in figure 6, even prohibiting access for security reasons.

Figure 6. Effects of storm Celia on the beaches adjacent to Sant Sebastià beach.

After this two-week period, Sant Sebastià beach recorded storm episodes lasting one to two days, which can be considered as typical events for the area.

The sediment on the emerged beach is coarse sand and about 0.7 mm in diameter, so initially no significant impact was expected at a depth of 8 m. However, the results of the OBS have shown a clear suspension of sediment at both depths (figure 7), corroborating the observed changes on the coast, which basically consisted of a retreat of the shoreline south of the beach and the flooding by the waves of practically the entire coast as reflected in figure 6.

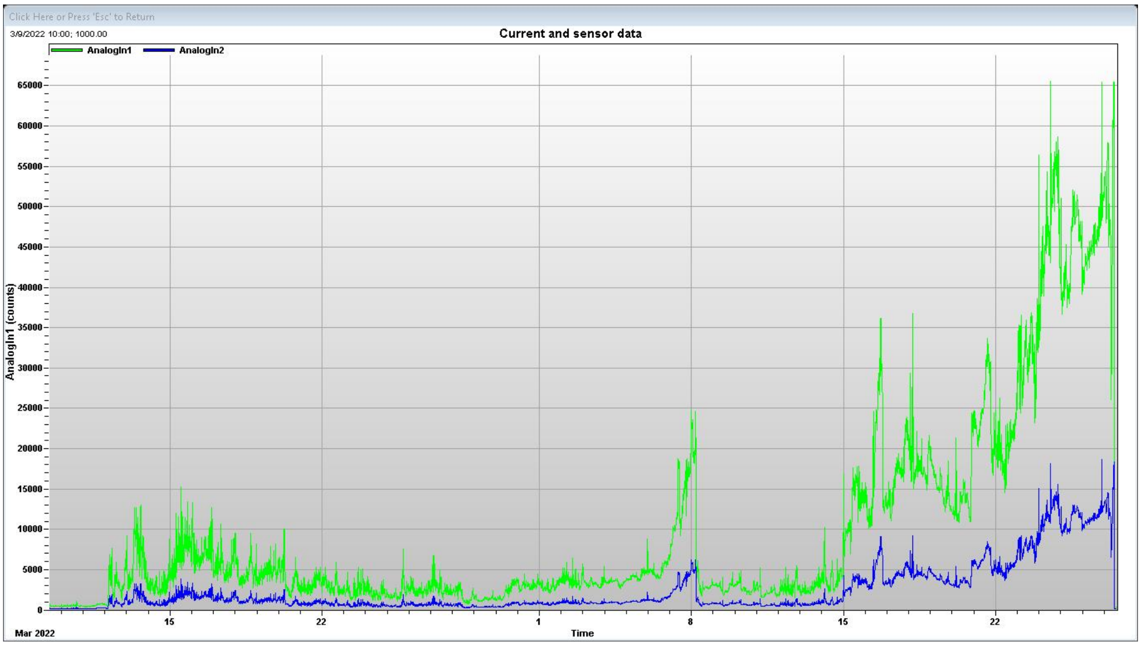

Figure 7. OBS turbidity records obtained at F1 deployment. Note that at the beginning of April the OBS shows a corrupted signal, most likely due to the accumulation of particles on the sensor.

Conclusions

The field campaign carried out on Sant Sebastià beach has made it possible to record one of the longest storm episodes on the Catalan coast, the Celia storm, which has caused severe impacts.

The gathered information of waves, currents, suspended sediment, bathymetry and sediment characteristics, as well as having a record of the damage caused, will allow the calibration and validation of the models used and therefore a reduction in the uncertainties and errors associated with the forecasts generated and the beach state.

The quality of the data obtained together with the reported damages are practically unique on the Catalan coast and therefore will be helpful in deepening our knowledge of the processes and impacts associated with such storm conditions.