

# 3D Modelling for the Dispersion of Sediments Dredged in the Port of La Rochelle with Open TELEMAC-MASCARET

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**Abstract**— In view of the future deepening operations in the port of La Rochelle (France), a 3D coastal model – including Ré and Oléron islands – was built with TELEMAC-3D and SEDI-3D to simulate the dispersion of the fine dredged sediments to be released at sea. The release scenario combined different sites and methods: two dumping zones with hopper dredger in the Lavardin shallows and in the Antioche Strait, and one submarine outfall in the La Pallice Strait. The model was adapted, firstly, to take wave contribution into account in the calculation of total (wave+current) bed shear stress, and secondly, to introduce the part of sediments maintained in suspension in the water column and the part deposited on the sea bottom during each release. The model proved to reproduce very satisfactorily the hydrodynamics in the straits as well as the known capacity of each disposal site to accumulate or disperse dumped sediments.

## I. INTRODUCTION

The mid- and long-term effect of fine sediment dumping at sea during port dredging operations often need to be simulated so that excessive turbidity and deposits – and associated mitigation measures – may be assessed. Finite-element-based softwares such as the open TELEMAC-MASCARET suite are commonly used to model the hydro- and sediments dynamics in complex environmental areas (tide, waves, wind, shallows...), see e.g. [1]. However, this kind of modelling is not always available off-the-shelf and programming adaptations are required to reproduce at best the release scenarios.

In view of predicting the effects of future deepening operations in the port of La Rochelle – PALR – (France), a 3D coastal model was built with TELEMAC-3D and SEDI-3D to simulate the fate of the fine sediments released after dredging and rock-breaking operations. The release scenarios involve two immersion types : dumping by trailing suction hopper dredger over two authorised sites (Antioche offshore in 24m mean water depth; the Lavardin shallows, close to La Rochelle, in 6m mean water depth) and submarine outfall discharge in the La Pallice Strait, after a decantation process of cuttings (tailings) inside a dedicated basin (La Repentie). The induced turbidity and deposits must be compared to the “natural” order of magnitude for the same period of the year (i.e. background turbidity and deposition) mainly due to the Gironde River discharges, strong hydrodynamic forces and low altimetry in the straits (mud flats). Concentrations up to several hundreds of mg/L may be observed, for instance, in the Bay of Aiguillon during spring tide and severe sea conditions.

Also, the “Pertuis Charentais” are well known for the many aquaculture farms deployed all over the area (e.g., Marennes-Oléron oysters), which are sensitive to natural turbidity conditions and deposits but possibly also to suspended matter dispersion from dumping sites.

Simulating such a scenario implies: 1/ the consideration of a directionally oriented outfall for the suspended load coming from the decantation basin – which is easy to set-up using default TELEMAC-3D options –, and 2/ a specific consideration of two sediment compartments released from the barge : the fine sediments maintained in the water column during the descent phase and the sediments deposited on the sea bed after collapsing. As TELEMAC-3D and SEDI-3D are used in a far-field approach, both types of releases need to be introduced as schematic source terms in the domain. Also, even if the transport of suspended sediment is mainly driven by the tidal current, both tidal currents and waves contribute to erode and/or to maintain in suspension fine sediments (see e.g. [2]). Therefore, wave conditions must be included in the calculation of the total bed shear stress at each time step. A previous “background” 2D wave simulation (including the effect of tidal currents and free surface elevation variations) is used here as an input of the 3D dispersion model.

This paper presents the TELEMAC-3D/SEDI-3D model that has been set-up in order to simulate a particular release scenario, whose results are plotted and mapped for illustrative purpose.

Section II introduces the study area (The “Pertuis Charentais”). Section III presents the construction of the model, including the validation of the 3D hydrodynamics, the sediment dynamic parameterisation, the source terms and the related implementations. Section IV highlights the relevance of the modelling strategy according to the simulation results, in particular the time evolution of the sediment mass deposited in each dumping zone and subject to local erosion. Section V finally concludes this work with some further perspectives.

## II. STUDY AREA

The study area covers the whole “Pertuis Charentais” located on the French Atlantic coast, including the region of La Rochelle (La Pallice Strait), the Aiguillon Bay, the Ré and Oléron islands, the Breton and Antioche Straits, as depicted in Fig. 1. The macrotidal regime (3 to 6m range) – in a maritime area with islands, straits, shallows and bays alternatively filled and emptied – induces significant flows that can reach 1 to 1.5m/s in Antioche and La Pallice straits in spring tide conditions. Oceanic swells

propagate through the Breton and Antioche straits where their energy is dissipated mainly due to refraction and bottom friction, in particular in the Breton Strait. Strong winds can also generate short-wave, wind-sea systems locally, which propagate through the straits and may therefore dominate over swells in these areas. In common situations, crossed seas are likely to be observed in the La Pallice Strait as the result of the meeting of waves from the Breton and Antioche straits.

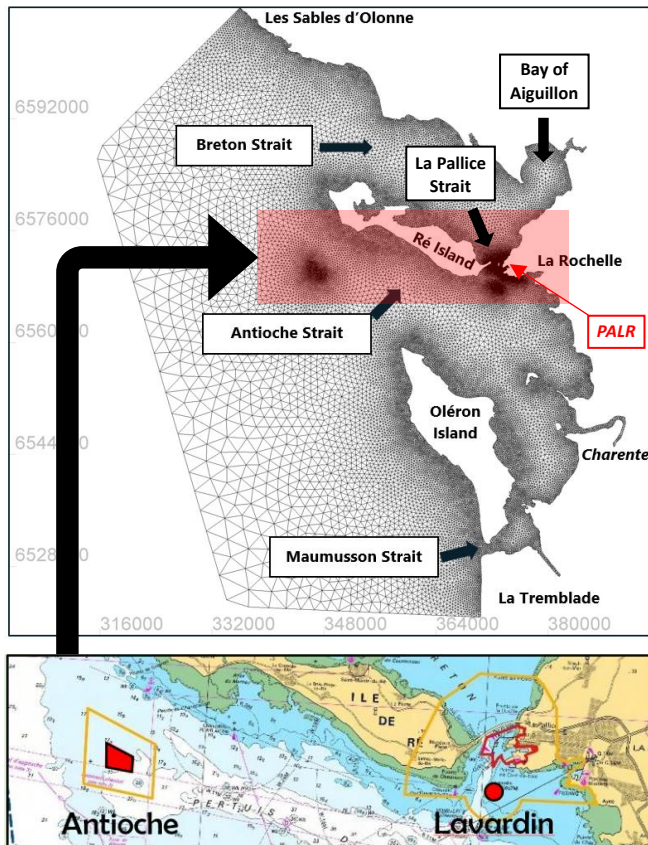


Figure 1 – Mesh of the “Pertuis Charentais” model with focus (below) on the two authorised dumping sites

Two main river outlets are present within and outside the domain, namely the Sèvre Niortaise, the Charente and the Gironde (further South). However, their contribution in terms of fine sediment input is not taken into account in this study.

The two authorised dumping sites – Antioche and Lavardin – are respectively located in the Antioche and La Pallice Straits (Fig. 1). The Lavardin site is defined within a 500m radius circle in the South of the La Pallice Strait (see Fig. 1). The bathymetry ranges between -4mCD and 0mCD and the seabed is a mix of sand and mud (mostly dredging material). The Antioche site is located South-West from Ré Island and is defined as an offshore trapezoidal (~2km<sup>2</sup> wide) area with sandy seabed around -20mCD.

The whole area is subject to environmental (Natura 2000 protected areas...) and socio-economic (fishing, shellfish farming, tourism...) concerns related to sediment transport and turbidity variations.

### III. SETUP OF THE DISPERSION MODEL

#### A. Modelling scheme

The scheme for the 3D dispersion modelling rests on an offline coupling (chaining) strategy. As the total contribution wave+current to the bed shear stress needs to be calculated at each time step by the 3D dispersion model for the calculation of erosion/deposition fluxes, a wave history is produced beforehand using a TELEMAC-2D/TOMAWAC coupled model. This option was preferred to a direct TELEMAC-3D/TOMAWAC coupling to reduce CPU times. The wave spectral peak period (TPR5) and spectrum-averaged bottom velocity (UWB) calculated by TOMAWAC – and influenced by tidal oscillations thanks to the coupling with TELEMAC-2D – are stored. Then, TELEMAC-3D and the embedded SEDI-3D module simulate the sediments release scenario : they respectively solve the 3D hydrodynamics (Navier-Stokes in hydrostatic mode) and suspended sediment concentration (SSC) transport-diffusion equations taking sediment source terms into account, as direct inflow in the water column, on the one hand, and bed deposits, on the other hand. The deposition and erosion fluxes are a function of an excess or lack of bed shear stress (relatively to critical bed shear stress for erosion or deposition), which is computed in SEDI-3D based on the hydrodynamic variables UWB and TPR5 at each time step. This, in turn, allows an update of the bed elevation, which may have an effect on 3D currents, especially over the Lavardin area. A general sketch of the modelling scheme is given in Fig. 2. The final output variables are the 3D SSC denoted by  $C$  [kg/m<sup>3</sup> or g/L] and mud deposit thickness denoted by  $\Delta z_b$  [m].

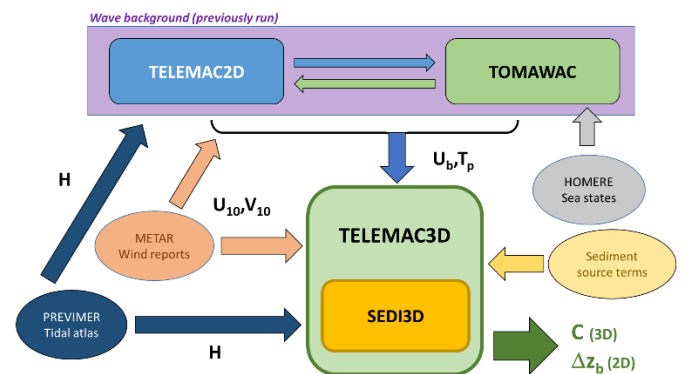


Figure 2 – Modelling scheme of the 3D dispersion model

### IV. HYDRODYNAMICS

#### A. Currents (TELEMAC-3D)

The hydrodynamic model is meshed using about 35 000 nodes with coarsest (2.5km) and finest (15m) resolution respectively along the open boundary and in the harbour zone. The resolution is also refined over the two deposit areas, as 50m in the Lavardin and 100m in Antioche. The water column is discretized as 5  $\sigma$ -distributed planes, which is deemed sufficient in a macrotidal context with limited depth. Height and velocities are prescribed on the liquid offshore boundary

using the PREVIMER tidal atlas (37 constituents with 250m resolution) and a time-varying homogeneous wind field drags the surface layers using the default Flather formulation [3]. The wind history is produced using METAR data (La Rochelle airport/LFBH). A homogeneous Strickler coefficient of  $40\text{m}^{1/3}/\text{s}$  is set up over the whole domain and the Smagorinsky model is adopted for horizontal and vertical turbulence closure. The Digital Elevation Model (DEM, Fig. 3) interpolated on the mesh was produced by merging different sets of data, including both the HOMONIM topo-bathymetric DEM for the Pertuis Charentais ( $0.0002^\circ$ ) [4] and bathymetric DEM for the Atlantic coast ( $0.001^\circ$ ) [5], a local bathymetric multibeam survey conducted in the harbour before 2018 and some recent bathymetric complements.

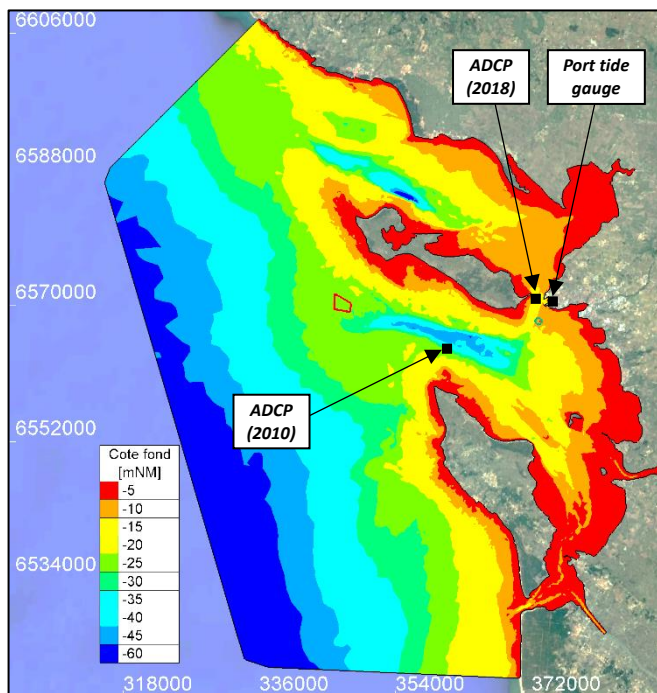


Figure 3 - DEM in reference to mean water level ( $+3.90\text{mCD}$  in La Rochelle) in Lambert 93 projection; location of available *in situ* level/current/wave measurement devices

The water level variations and 3D currents were validated against *in situ* measurements (see Fig. 3):

- tide gauge records in octobre-novembre 2016 in the harbour of La Rochelle-La Pallice ( $46.158501^\circ\text{N}$ ,  $1.22065^\circ\text{W}$ ),
- data from ADCP deployed in February-March 2010 by the SHOM in the Antioche Strait ( $46.0919^\circ\text{N}$ ,  $1.3940^\circ\text{W}$ ) (currents mostly going  $\text{W}\langle\text{E}$ )
- data from ADCP deployed in octobre-novembre 2016 in the La Pallice Strait ( $46.1596^\circ\text{N}$ ,  $1.2423^\circ\text{W}$ ) (currents going mostly  $\text{N}\langle\text{S}$ ).

The comparison between measurements and results is shown in Fig. 4. For 3D currents, surface and bottom signals along the dominant axis only are shown (i.e., U-component in Antioche and V-component in the La Pallice Strait) for the sake of conciseness.

Water level in the harbour was satisfactorily reproduced, with a RMSE of 16cm. Simulated 3D currents (surface, mid-height and bottom) were also found in good agreement with measurements, with 13 to 27cm/s RMSE for U-component in Antioche and 15 to 21cm/s for V-component in La Pallice. In particular, ebb/flow asymmetries appeared to be well predicted.

#### B. Waves (TELEMAC-2D/TOMAWAC)

The wave history was generated by coupling TELEMAC-2D and TOMAWAC with the following boundary conditions: PREVIMER atlas for water level and currents; HOMERE reanalysis data [6] for sea states, through wave parameters  $H_{m0}$ ,  $T_p$  and  $\theta_p$  (virtual buoy “W184N4598”). These parameters were shown to vary little along the offshore boundary so that a homogeneous JONSWAP/ $\cos^{2s}$  directional spectrum could be assumed at each time step (mean shape parameters  $\gamma$  and  $s$  were estimated based on the HOMERE data). As in the TELEMAC-3D model, METAR wind data have been considered for surface current driving and wave generation.

The sea states simulated by the model in the La Pallice Strait were compared to the ADCP wave measurements covering the October-November 2016 period. The simulated significant wave heights  $H_{m0}$  showed to be in good agreement with ADCP data (RMSE of 15cm), as depicted in Fig. 4. Due the limited information on sea state multimodality (superposition of swell(s) and wind-sea) in the offshore data used as boundary conditions, the peak period ( $T_p$ ) could not be accurately reproduced in calm situations, when the wind-sea dominates in the straits. Wave directionality was not deemed useful either for comparison, also because of many disturbance effects in the deployment site (wave diffraction and reflection, boat wakes...). However, as wave directionality is not taken into account in the deposition/erosion flux calculations (see §V), suspended sediment dynamics are not affected by the quality of directional results. Moreover, as bottom orbital velocities tend to be overestimated in calm wave situations due to the own  $T_p$  overestimation, this results in conservative calculated bed shear stress values – which, in turn, induces conservative turbidity levels – an acceptable approach for our study.

### V. SEDIMENT RELEASES

#### A. Characterisation of released sediments and work scenario

The deepening works in the port consist in dredging the superficial muddy layer and cutting/dredging the underlying marl/limestone layers up to a certain operational level.

A total of  $375\,000\text{m}^3$  of sediment (the figure is only illustrative, here) is dredged in the port from which the fine – cohesive ( $\varnothing < 63\mu\text{m}$ ) – part is then released into the sea. A sandy fraction is also expected in the mix but not studied here as it does not contribute to turbidity. The representative dry concentration of mud fraction is estimated around  $650\text{kg}/\text{m}^3$  based on PALR’s assumptions. According to the capacity of the hopper dredger, a mass of about 600t of sediments is to be

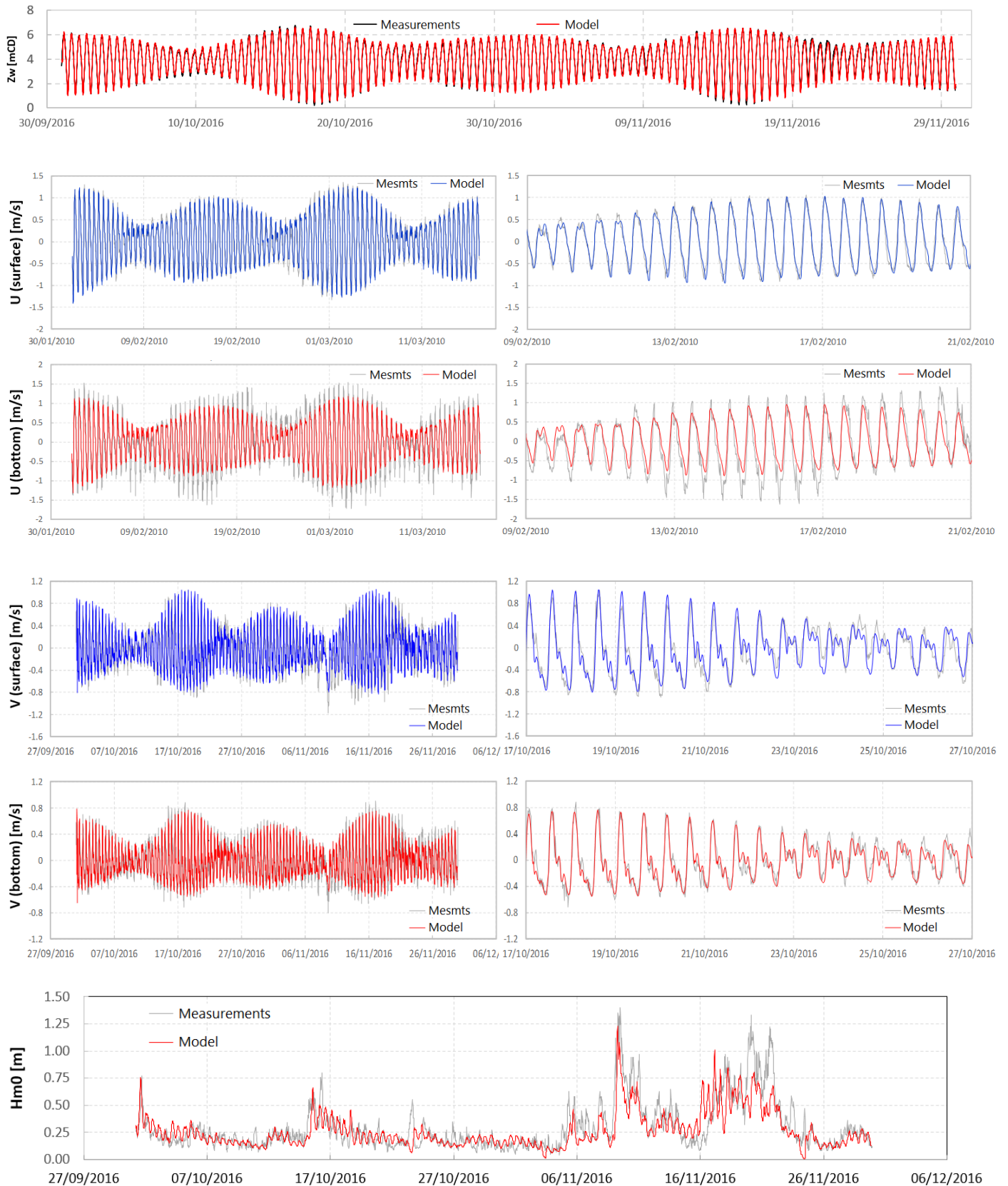


Figure 4 – Comparison of simulated 3D currents and significant wave height against in situ ADCP measurements (Antioche, La Pallice)

released at each rotation (in the Lavardin or Antioche). A 30% Lavardin / 70% Antioche repartition is assumed so that 122 and 284 rotations are planned for disposal at each site respectively. Releases at high tide are required at the Lavardin because of the shallow bathymetry.

The volumes of marl excavated by the cutter suction dredger (rock-breaking) are deposited into the close-by decantation basin of La Repentie. Due to aspiration and continuous disintegration, a significant load of suspended matter is obtained in the basin, which can be partly adjusted using flocculating agents. It is assumed here that the SSC never exceeds 1g/L. As the basin is progressively filled with sediments, the corresponding volume of water is sent back to the sea with an outfall pipe located under the bridge leading to the oil terminal in the middle of the La Pallice Strait (Fig. 5). The release – SW-oriented on the sea bottom – is supposed to be continuous during the rock-breaking operations, with maximum authorized flow rate of 10 000m<sup>3</sup>/h (i.e., 2.78m<sup>3</sup>/s) and constant SSC of 1g/L.

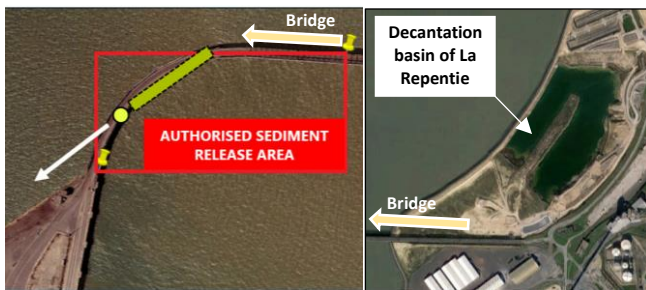


Figure 5 – (Left) Location of submarine outfall in the La Pallice Strait for the release of turbid waters from the decantation basin; (Right) decantation basin of La Repentie

A timeline of the release scenario simulated in this study is depicted in Fig. 6. The dumping operations in Antioche and Lavardin are planned over 63 days: they start as soon as the port deepening dredging starts, with one release around each high tide in the Lavardin and 2 or 3 releases in Antioche in between. After 28 days, the outfall release in the La Pallice Strait is launched for about 10 weeks (duration of rock-dredging operations in the port). “T0” here refers to the work start in mid-December of year N, after a 24h transient phase for hydrodynamics setting up. The rock-breaking and releases stop around mid-March of year N+1.

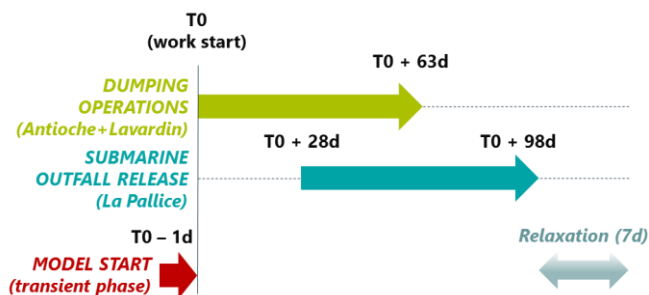


Figure 6 – Timeline (not scaled) of release operations during the port deepening works in La Rochelle

## B. Sediment dynamics and source terms

The modelling of sediment dynamics in SEDI-3D rests on the usual formulations for cohesive sediments, namely the Krone law for deposition flux :

$$D = w_s C \left[ 1 - \frac{\tau_b}{\tau_{cd}} \right] \quad (1)$$

where  $w_s$  [m/s] denotes settling velocity and  $\tau_{cd}$  [N/m<sup>2</sup>] the critical bed shear stress for deposition, and the Partheniades law for erosion flux:

$$E = \text{Max} \left( 0; M \left[ \frac{\tau_b}{\tau_{ce}} - 1 \right] \right) \quad (2)$$

with  $M$  the erosion constant [kg/m<sup>2</sup>/s] and  $\tau_{ce}$  [N/m<sup>2</sup>] the critical bed shear stress for erosion.

The total bed shear stress ( $\tau_b$ ) needs to be calculated at each node and each time step. In SEDI-3D, the wave-induced stress is not included by default. As this contribution must be taken into account, it was included in the CLSEDI routine as follows.

The total stress is calculated in a conservative approach as:

$$\tau_b = \tau_c + \tau_w \quad (3)$$

where:

- $\tau_c = \rho u_*^2$ , the shear stress due to currents, with  $\rho = 1025 \text{ kg/m}^3$  the sea water mass density and  $u_*$  the friction velocity, calculated here using the Nikuradse formula with rugosity coefficient  $k_s = 1 \text{ mm}$  ;
- $\tau_w = \frac{1}{2} \rho f_w U_w^2$ , the shear stress due to waves expressed as a function of the maximum orbital velocity  $U_w$  [m/s] (UWB from TOMAWAC here) and  $f_w$  [-] the wave friction factor following the default Swart [7] formula (involving UWB and TPR5).

Directional difference between currents and waves is not taken into consideration for simplicity.

As parameters like deposition/erosion critical bed shear stresses ( $\tau_{cd}$ ,  $\tau_{ce}$ ) and bed concentration (denoted as  $c$  here) may be different for partly aggregated muds immediately deposited on the bottom and released particles deposited after having been advected (fresh deposits), two classes of sediments were setup in SEDI-3D (Fig. 7). The same critical stress values were used for both classes here ( $\tau_{cd} = 0.1 \text{ N/m}^2$  and  $\tau_{ce} = 0.2 \text{ N/m}^2$ ) but the deposits were modelled as slightly denser ( $c_1 = 300 \text{ kg/m}^3$  vs.  $c_2 = 200 \text{ kg/m}^3$ , typical value for fresh deposits), which has an impact on bed thickness only. The settling velocity ( $w_s$ ) was set to  $2.2 \cdot 10^{-4} \text{ m/s}$  and the erosion constant  $M$  was given the value  $5 \cdot 10^{-5} \text{ kg/m}^2/\text{s}$ . Most of these values were obtained in previous studies commissioned by PALR.



Figure 7 – Sediment layer definition in SEDI-3D

For simplicity, the dredger is assumed to release sediments from the same location in both Lavardin and Antioche sites. The released mass of sediments is divided in two parts: 13% are maintained in suspension during the descent phase (78t) while 87% of the mass (522t) remains on the sea bed after dynamic collapsing. This repartition is estimated based on dredger experience but might as well be approached using specific nearfield modelling softwares like e.g. ST-FATE [8].

At the centre of each disposal site, source points are defined at all planes but the first one (seabed), with identical mass flux ( $\sim 65\text{kg/s}$  on each plane), as depicted in Fig. 8. The total duration of each release is 5min.

In order to introduce the right amount of sediment deposited on the sea bottom at each time step during the release, a sediment layer increment is applied as soon as suspended matter is released from the dredger (in ERODC subroutine). The layer increment is restricted to a certain area representing the footprint of the release and deemed homogeneous on that area. The dumping area can be estimated using, nearfield modelling, among others. Here, as a unit release simulated with ST-FATE was shown to induce a rather limited deposit area at both sites ( $10\,000$  to  $100\,000\text{m}^2$ ), an averaged dumping area – standing for all rotations – was assumed, extending over  $150\,000\text{m}^2$  in the Lavardin and  $1\,000\,000\text{m}^2$  in Antioche (within the zones depicted in Fig. 1). It is checked *a posteriori* that the mass of sediments introduced on the bottom at each rotation (522t) is correct.

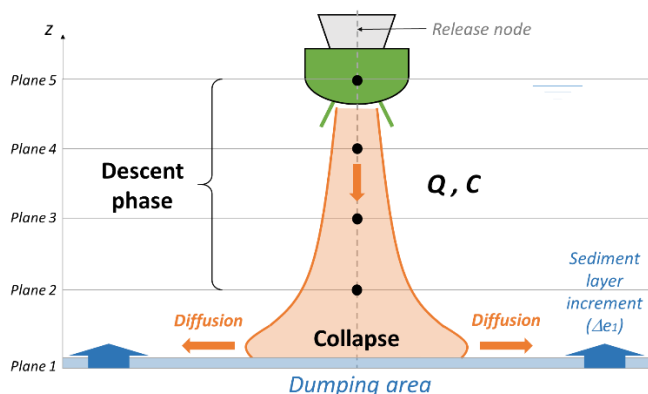


Figure 8 – Source term definition in SEDI-3D for dumping: four source points (planes 2 to 5 at release node) with prescribed suspended matter discharge and sediment layer increment on the disposal area

The submarine outfall is simulated as a typical source point located on the sea bed with given discharge, SSC, duration and direction (SW-oriented jet), as described earlier.

## VI. MODELLING RESULTS

### A. Hydrodynamic conditions

The wave-, current-induced and total bed shear stresses calculated by the model along the simulation at one representative point in both deposit sites are depicted in Fig. 9 and 10 (top). The simulated wave-induced stress ( $\tau_w$ ) generally is an order of magnitude higher than the current-induced stress

( $\tau_c$ ). The total stress ( $\tau_b$ ) never exceeds  $3\text{N/m}^2$  over the Antioche area, with peaks in the range  $[0.5;2.5\text{N/m}^2]$ . In the Lavardin site, waves are weaker than in Antioche so that their contribution to the total stress is also smaller: peak stress values are calculated in the range  $[0.1;1.5\text{N/m}^2]$ . All stress signals are influenced by tide, either due to the oscillatory flow or the effect of depth variation on waves.

### B. Turbidity

The bottom/surface SSC (in  $\text{mg/L}$ ) at both sites is also depicted in Fig. 9 and 10 (centre). As most of the dumped volumes are deposited on the seabed (87%) and also due to the own SSC gradient induced by settling velocity, bottom concentrations are systematically found higher than surface ones, especially in Antioche. In the Lavardin shallows, bottom and surface SSC are closer to each other due to stronger mixing and limited depth, which reduce the vertical SSC gradient. The calculated bottom concentration peaks reach  $100\text{mg/L}$  (up to  $280\text{mg/L}$ ) in Antioche and  $200\text{mg/L}$  (up to  $340\text{mg/L}$ ) in the Lavardin. A correlation to the total bed shear stress is found for bottom (and surface, to a lesser extent) SSC in Antioche. Although this be less clear on the curves, the same kind of dependence is observed in the Lavardin, where outfall releases also are contributing – although not significantly – to the resulting turbidity.

Figure 11 illustrates a sequence of bottom SSC in Antioche and the Lavardin at different stages of the tide on day 47 of the simulation – when dumping operations and outfall discharges are both ongoing and erosion rates are high. Dumping releases are taking place in flow- and ebb-tide in Antioche and just before high tide in the Lavardin. The simulated plumes are due to the releases at both dumping sites as well as resuspension of previously deposited sediments.

### C. Evolution of sediment deposits

The instantaneous mass of sediment integrated over each dumping area is plotted in Fig. 9 and 10 (bottom). It is verified (see figure insets) that a mass of approximately 522t is introduced on the bottom (layer 1) at both sites during each dumping phase. In Antioche, the high bed shear stress levels cause a rapid erosion of the deposits. During calm periods, sediments may accumulate (up to  $12\,000$ - $13\,000\text{t}$  here around days 20 and 60) but do not remain longer than about ten days. On day 60, the accumulation stops because in the release scenario, dumping ceases in Antioche and is continued for about 4 days in the Lavardin only. The site of Antioche as simulated with the 3D model is therefore highly dispersive, which is consistent with PALR's experience. In the Lavardin, the deposited sediments tend to accumulate in spite of a slight, regular erosion – too small, however, to erode the whole of the dumped volume. The sediment mass therefore is continuously increasing during the barge rotations up to about  $38\,000\text{t}$  (over nearly  $64\,000\text{t}$  if no erosion occurred). On day 64, the dumping ceases and the deposits erode progressively. At the end of the simulation, nearly half of the volume has been eroded, so that a duration of about 3 months would be probably required to disperse it entirely. This is also consistent with PALR's experience (frequent bathymetric surveys), evoking no long-term accumulation trend in the Lavardin.

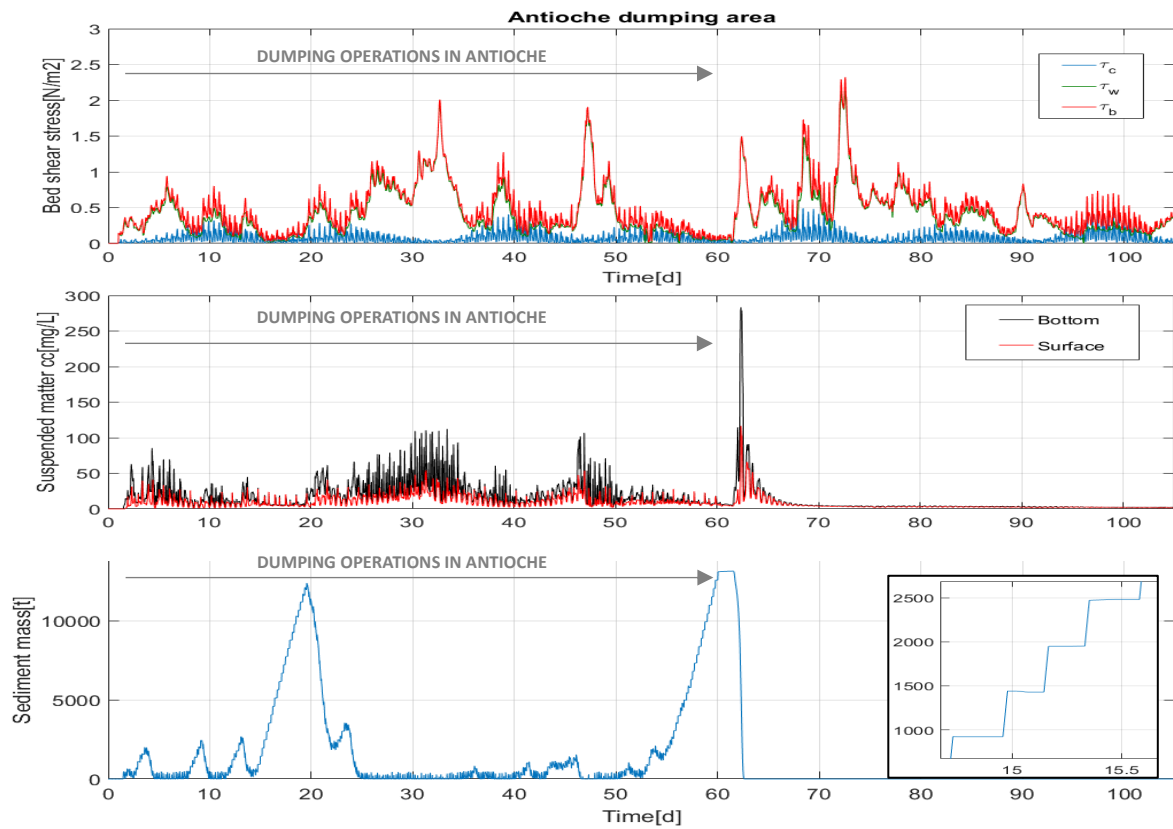


Figure 9 – Current-, wave-induced and total bed shear stress (top), SSC (centre) and total sediment mass deposited (bottom) in the Antioche dumping site as simulated by the 3D model; dumping in Antioche stops on day 60.

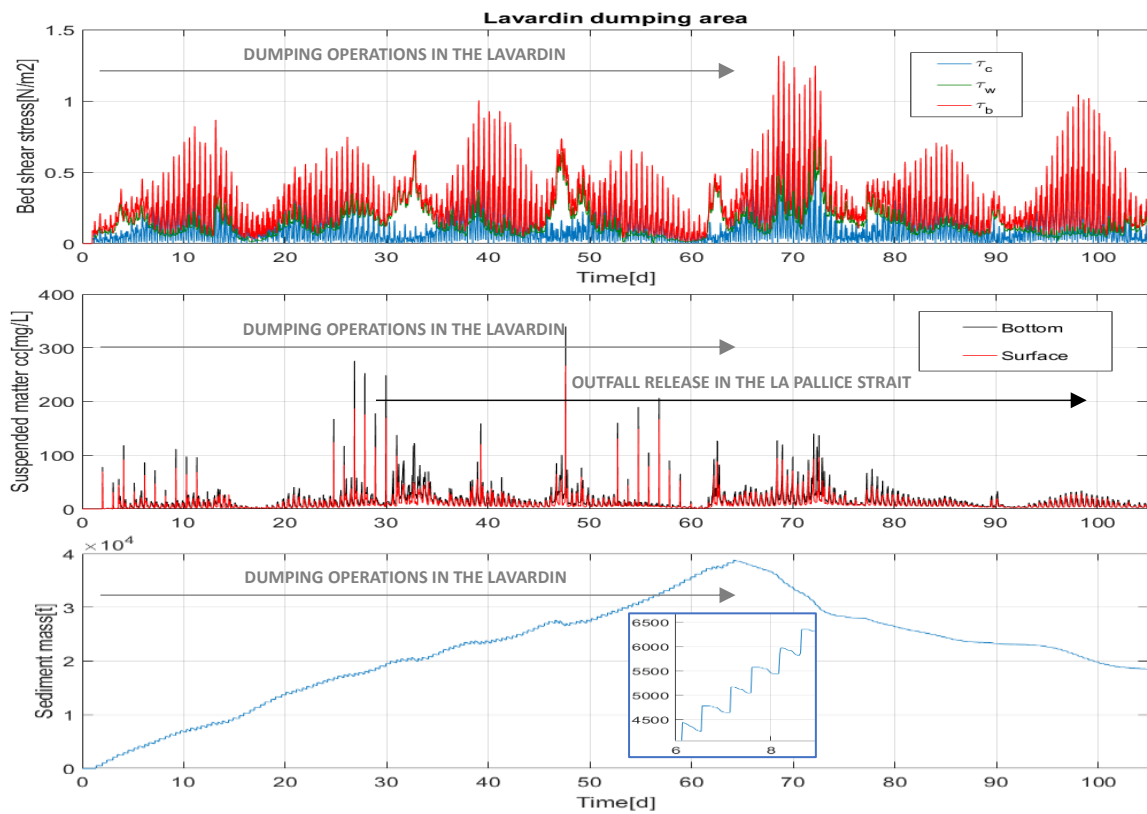


Figure 10 – *Idem* fig. 9 in the Lavardin dumping site; dumping stops in the Lavardin on day 64; outfall release starts in the La Pallice Strait on day 29 and stops on day 99.

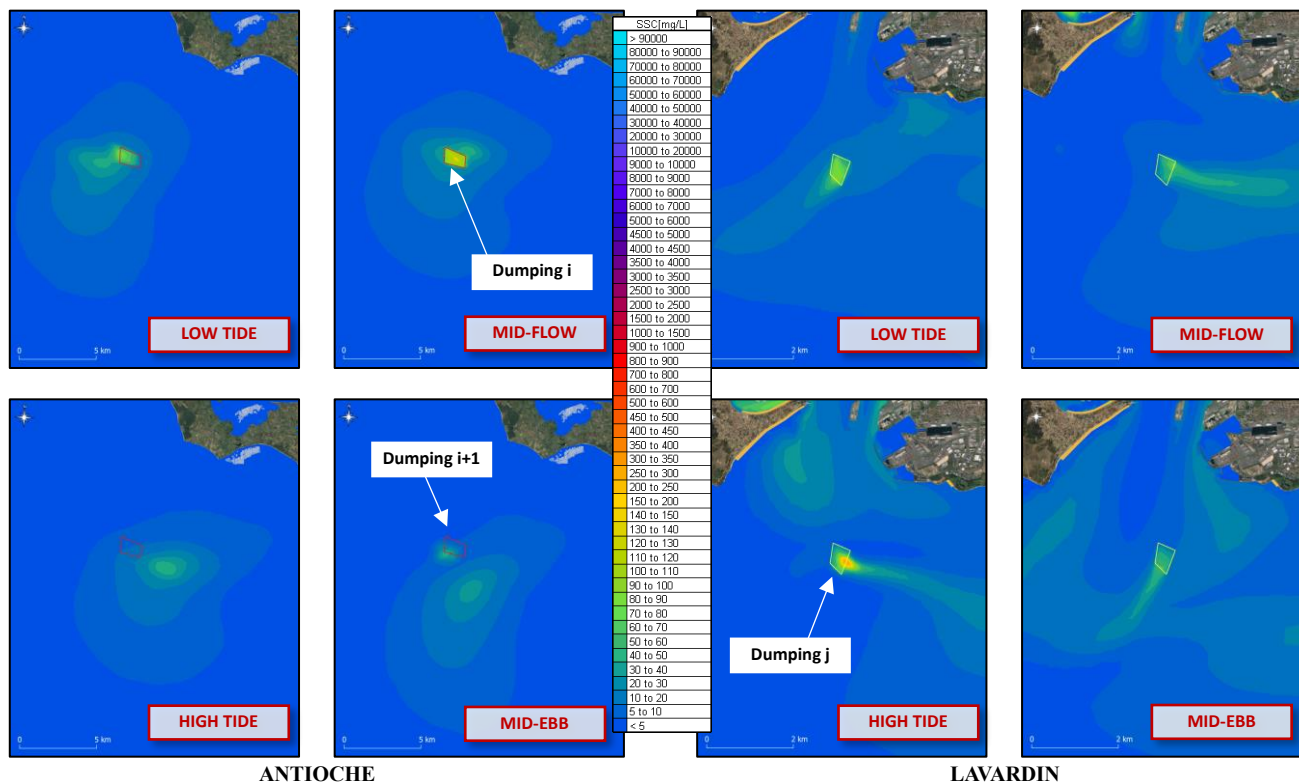


Figure 11 – Sequence of (bottom) SSC[mg/L] around high tide on day 47 of the simulation in Antioche (left) and Lavardin (right) dumping sites (dumping occurring during flow- and ebb-tide in Antioche and near high tide in the Lavardin).

## VII. CONCLUSIONS AND FURTHER WORK

The TELEMAC-3D/SEDI-3D dispersion model constructed in view of assessing the effects of the future deepening works in the port of La Rochelle (PALR) has shown to behave very satisfactorily as regards hydrodynamics and the main trends of sediment dispersion. In particular, the simulated capacity of the Antioche and Lavardin dumping sites to store or disperse the deposited sediments confirmed PALR's empirical knowledge, that is : no persistence of sediments in Antioche and persistence over a period of time not exceeding a couple of weeks/months in the Lavardin, according to the volume of dredged sediments considered ( $375\,000\text{m}^3$  *in situ* here distributed on both sites). Such a modelling strategy can be applied to any release scenario in coastal areas with limited depths. Further refinements could be conducted, namely on the calculation of the total bed shear stress (current-wave interaction) in association with a better representation of the sea state contents in the domain in case field data are available.

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## REFERENCES

- [1] R. Walther, C. Cayrol, L. Hamm, A. Delouis and D. Leahy, "Evaluation of an offshore disposal site in the Loire estuary through field monitoring and 3D numerical modelling," *Proc. of Int. Conf. on Coastal Engineering*, vol. 1, n°34, pp. 1-15, 2014.
- [2] P. Le Hir, S. Kervella, P. Walker and I. Brenon, "Erosions, dépôts et transits sédimentaires associés dans le bassin de Marennes-Oléron," *La Houille Blanche (SHF)*, n°5, pp. 65-71, 2010.
- [3] O. Mattic, "Telemac3d – User Manual, Version v7p3," 90pp., 2018.
- [4] SHOM, "MNT Topo-Bathymétrie Côtier des Pertuis Charentais (Projet Homonim)," 2015 [<https://diffusion.shom.fr>].
- [5] SHOM, "MNT Bathymétrie de Façade Atlantique (Projet Homonim)," 2015 [<https://diffusion.shom.fr>].
- [6] E. Boudière, C. Maisondieu, F. Ardhuin, M. Accensi, L. Pineau-Guillou and J. Lepesqueur, "A suitable metocean hindcast database for the design of Marine energy converters," *Int. Jour. of Marine Energy*, pp. 40-52, 2012.
- [7] D. H. Swart, "Offshore sediment transport and equilibrium beach profiles," Technical report, Delft University, Delft Hydraulics Publication 131, 1976.
- [8] B. H. Johnson, "User's guide for models of dredged material disposal in open water," U.S. Army Engineer Waterways Experiment Station. Dredging Operations Technical Support Program, Technical Report D-90-5, 1990.