Wave attenuation modelling by beach nourishment in the coastal area of U-Minh district

1. Introduction

Coastal monitoring data for U Minh showed that erosion has increased in recent years. To mitigate this negative impact, many of the construction measures have been developed by the local authorities. In order to find a suitable and effective solution to protect the U-Minh coast, this study aims to simulate the effect of beach nourishment (BN) on the coast protection in reducing wave energy. This solution is expected to reduce erosion caused by waves to the protected area.

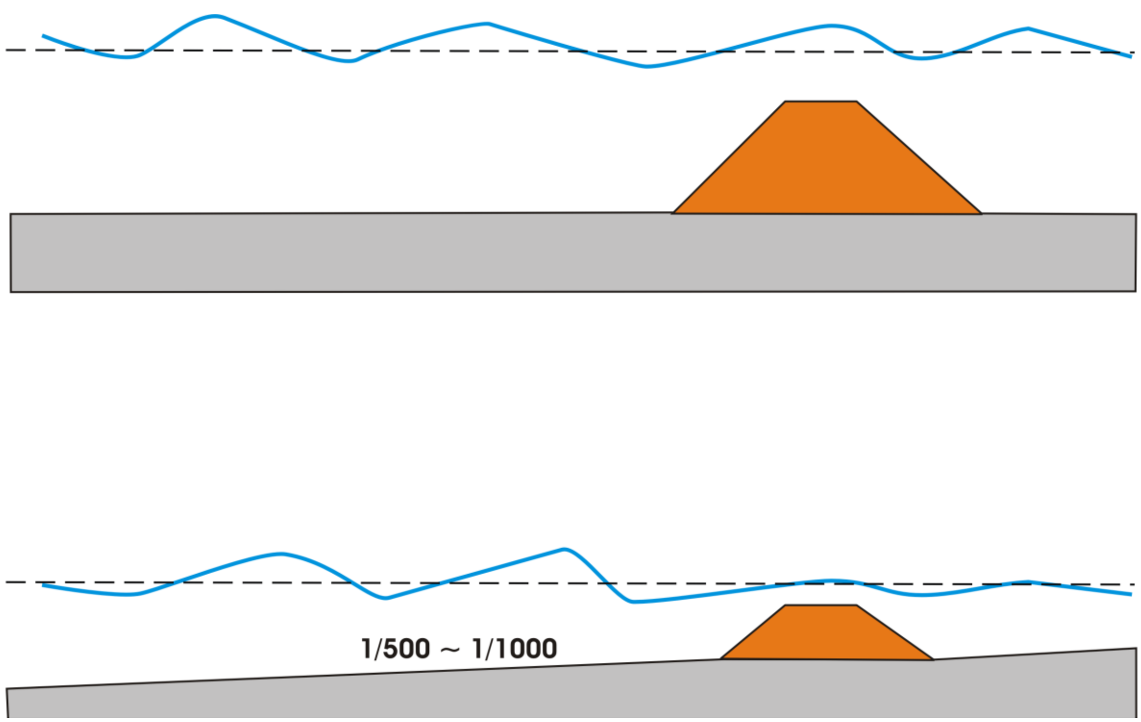

Figure 1.1: Typical type of beach nourishment for wave attenuation

In order to study this erosion process, various numerical models are used simultaneously including Telemac2D (hydrodynamic), Tomawac (wave) and Sisyphe (sediment transport). The detailed computing mesh including beach nourishment will focus on the zone from the Bay-Hap to Ong Doc River.

2. Study area and boundary conditions

The local area of interest is the western coastal area of the Mekong Delta, which is confined to the south, abutting the Gulf of Thailand. The average width is 40 km from the coast and 126 km from Ca Mau Cape to the north. This study area is characterized by 87 thousand unstructured triangle elements of which the largest mesh is up to 2000m (offshore elements) and the smallest is 8m (or 3m in case of built-in wavefronts) for the coastal zone.

To assess the impact of BN on coastal erosion and accretion, two size options are examined. Each zone is arranged parallel to the shoreline and about 800m - 1000m from shore:

- Option 1: The BN's dimension is B = 60m in width, L = 7000m in length and H = 1.7m (Z≈0m) in height (from original bed), about 800m ÷ 1000m from coast.
- Option 2: The BN's dimension is B = 120m in width, L = 7000m in length and H = 1.7m (Z≈0m) in height, about 800m ÷ 1000m from coast..
- Option 3: The BN's dimension is B = 120m in width, L = 7000m in length and Z = 0.2m in height (about 600m ÷ 700m from coast)

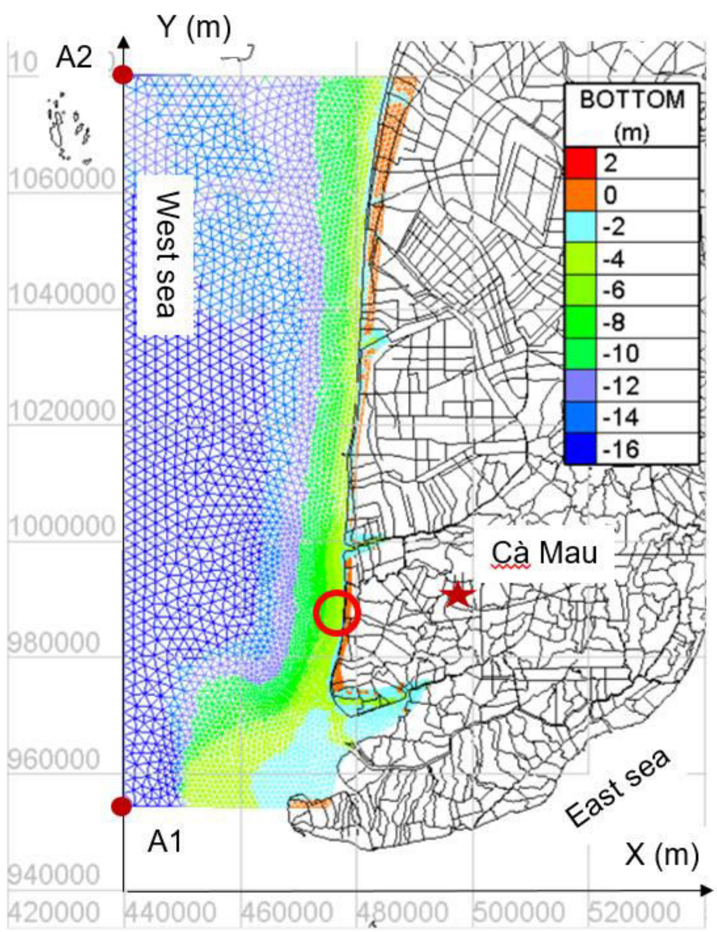

Figure 2.1a: Local study area

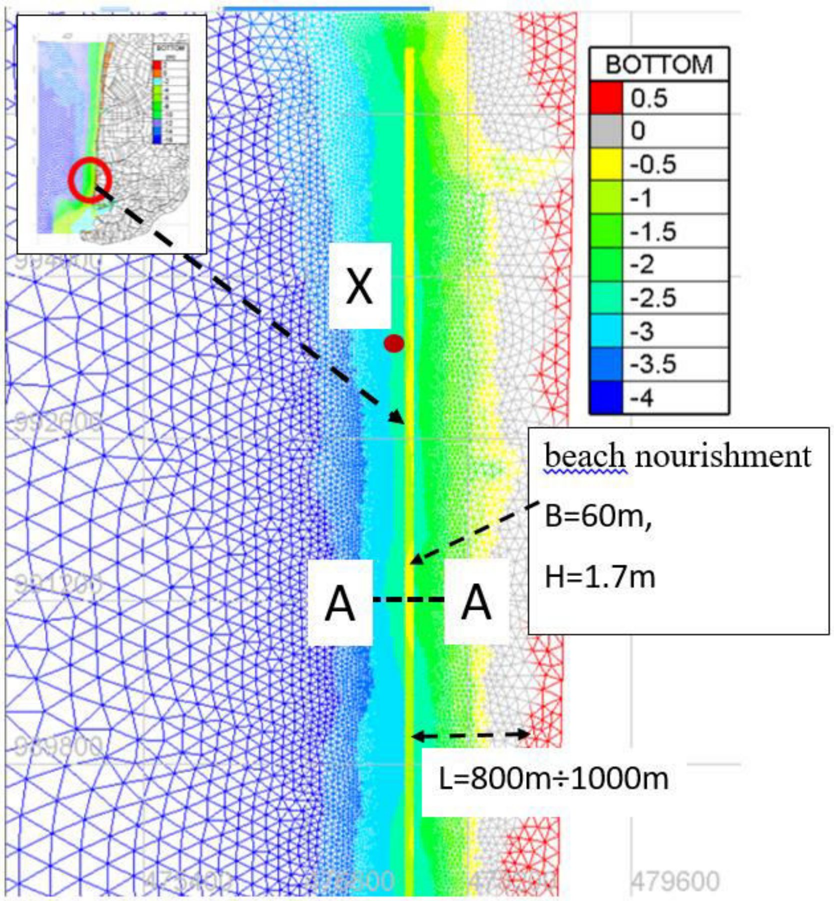

Figure 2.1b: Simulation of nourishment bed in study area

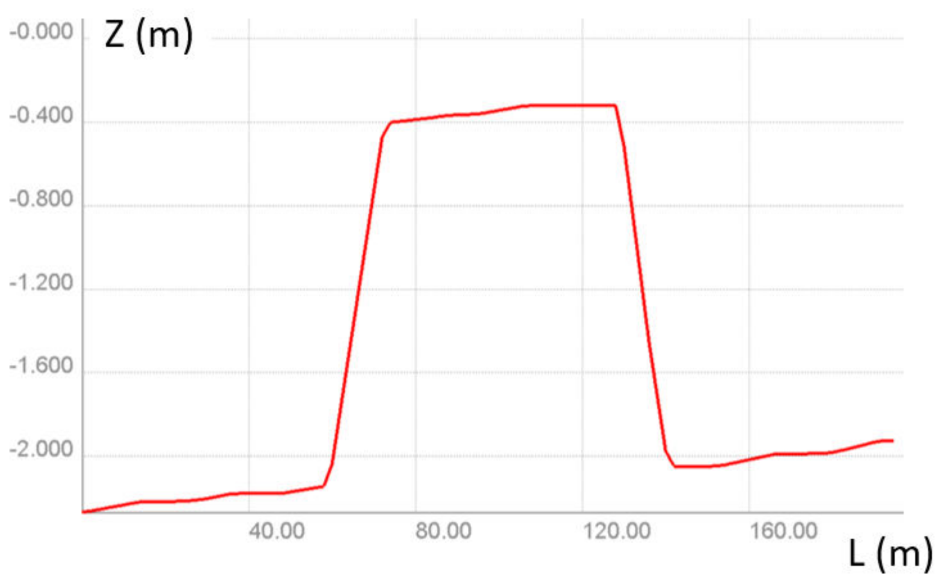

Figure 2.1c: Cross-section A-A, dimension of BN is B=60m in width and H=1.7m height

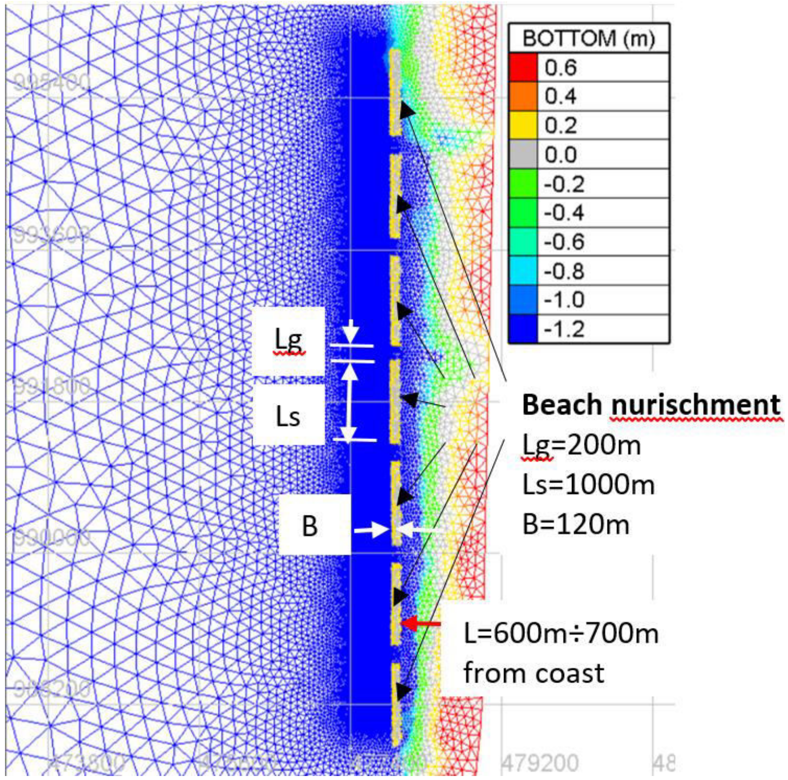

Figure 2.1d: Simulation of nourishment interrupted bed in study area

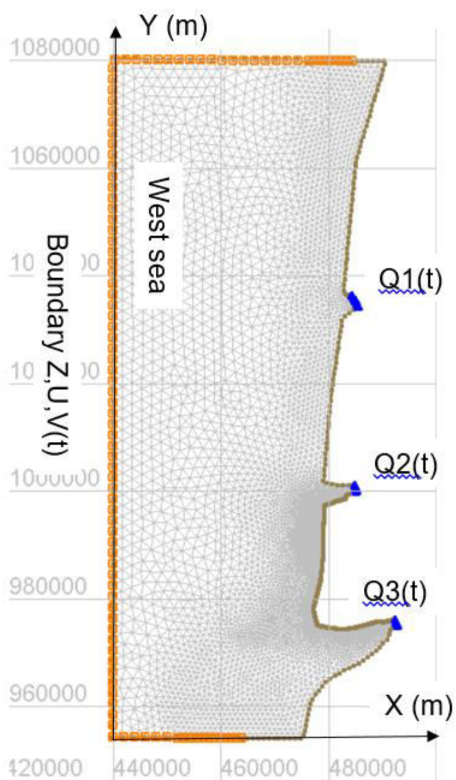

Figure 2.2: Boundary conditions

Tidal: The open boundary at offshore is determined from astronomical tide extracted from TPXO database during the study period.

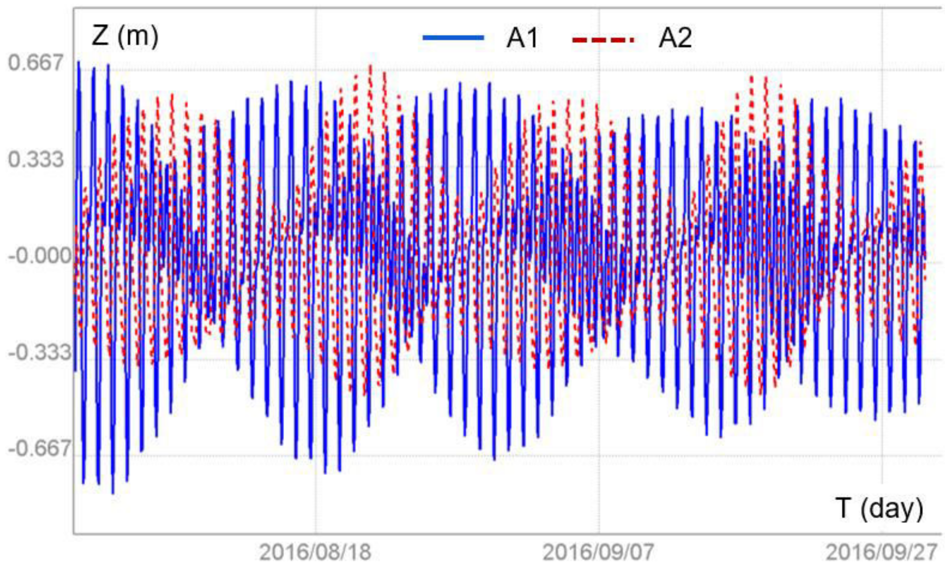

Figure 2.3: Tide boundary at typical positions A_1 and A_2 during Aug. & Sep 2016

At the open boundary, wave data is determined from a global database of wind and wave effects on the surface domain determined from NOAA for the boundary conditions of the Tomawac model.

Wave and Wind: At the open boundary, wave data is determined from a global database of wind and wave effects on the surface domain determined from NOAA for the boundary conditions of the Tomawac model.

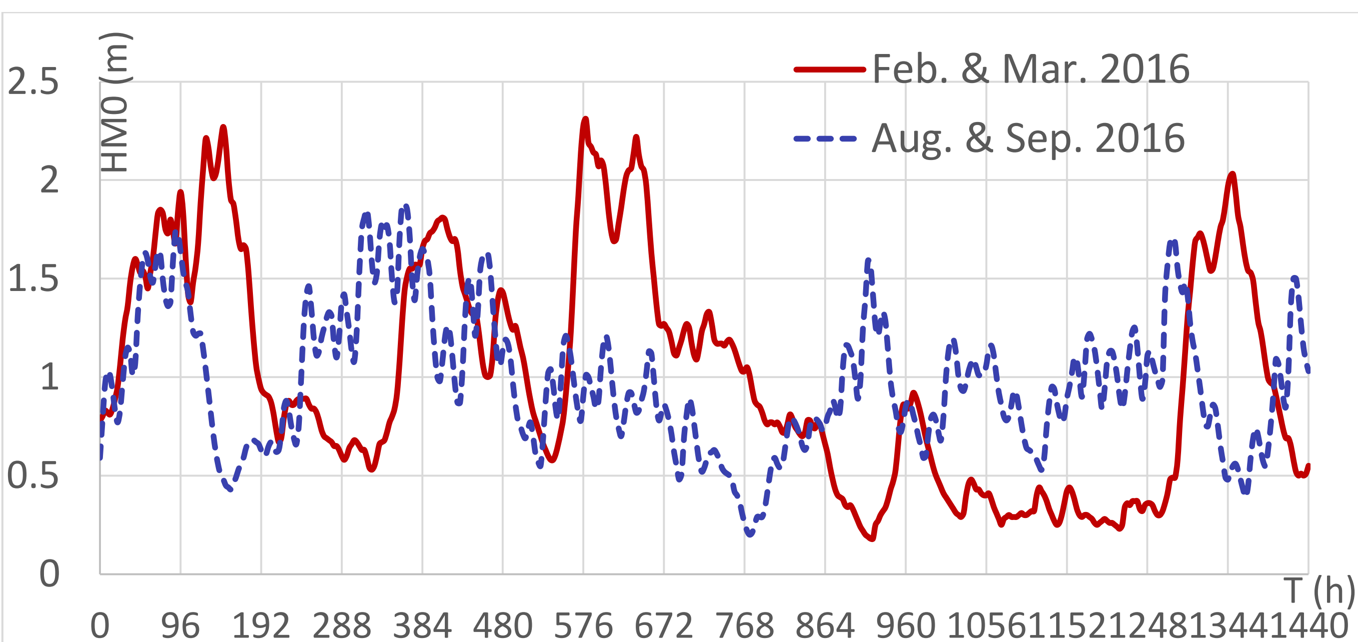

Figure 2.4a: Wave height HM0 from NOAA at coordinates (334682.9 ; 884599.1)

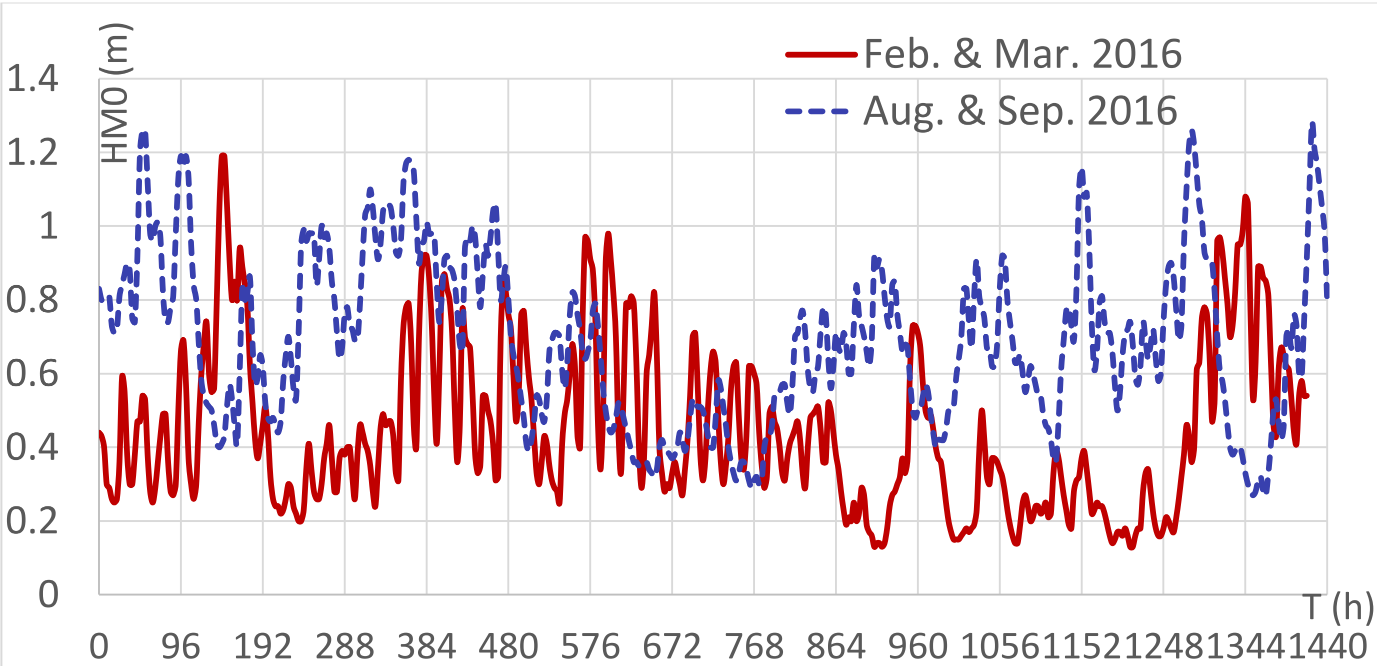

Figure 2.4b: Wave height HM0 from NOAA at coordinates (335343.7 ; 1050487.3)

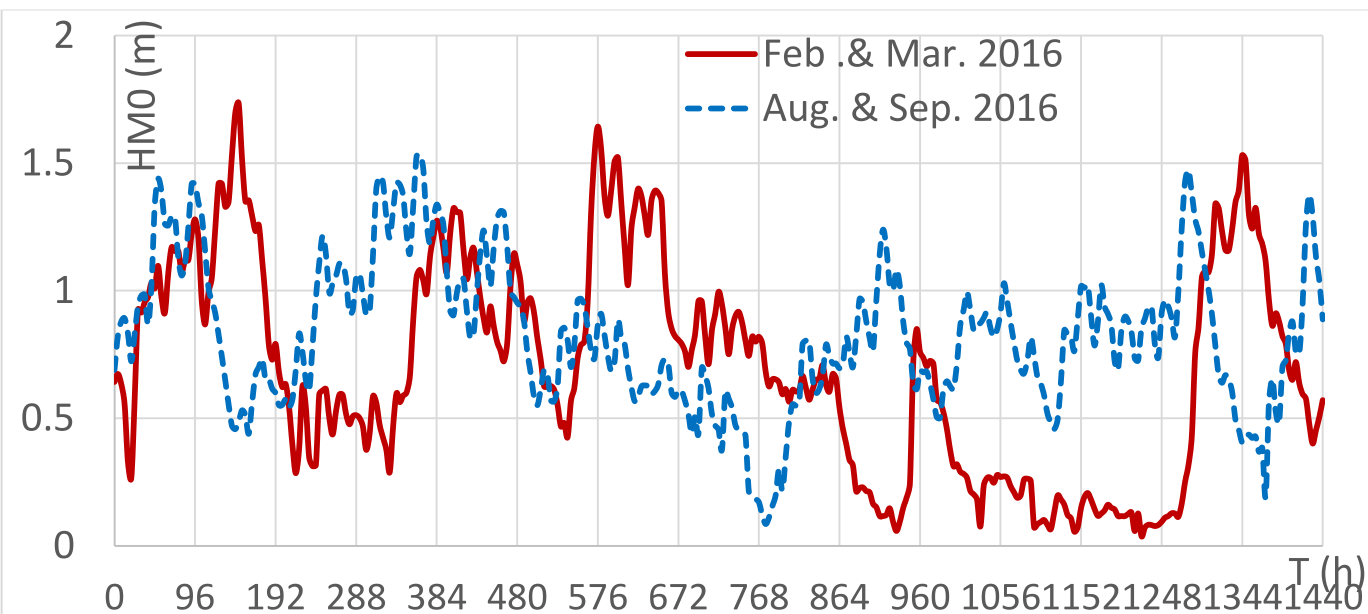

Figure 2.4c: Wave height HM0 from NOAA at position A1 of coordinates (439869.6 ; 954419.1)

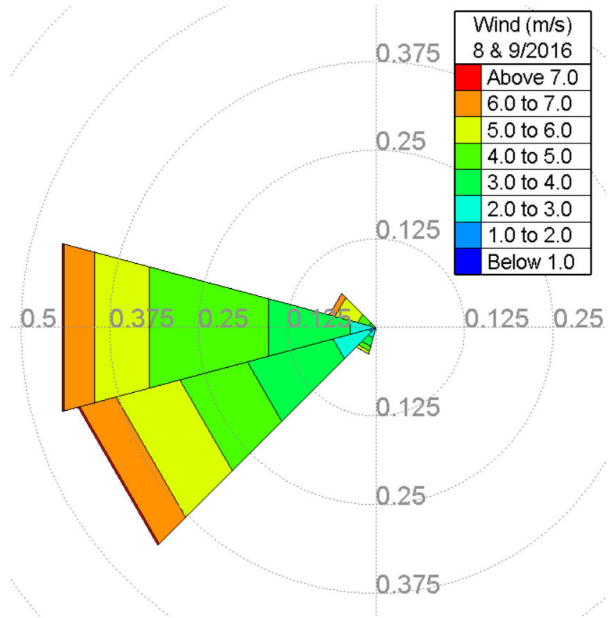

Figure 2.5a: Typical wind rose in U-Minh coast at location X in 8-9 /2016

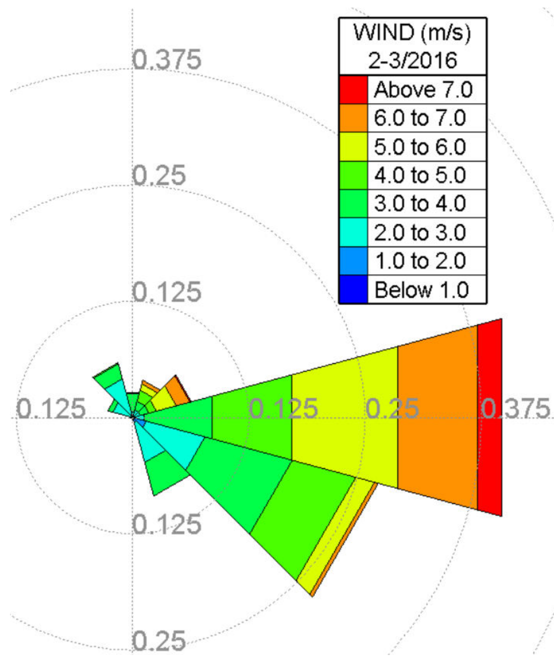

Figure 2.5b: Typical wind rose in U-Minh coast at location X in 2-3 /2016

The results from the wind rose show that these are two distinctly monsoonal periods. In the months of January & February, the winds are relatively intense compared to August and September. Wind direction in January & February is mainly from the East, while in August and September, it is mainly in the west and southwest.

Discharge: Discharge in Ong-Doc river are taken as follow:

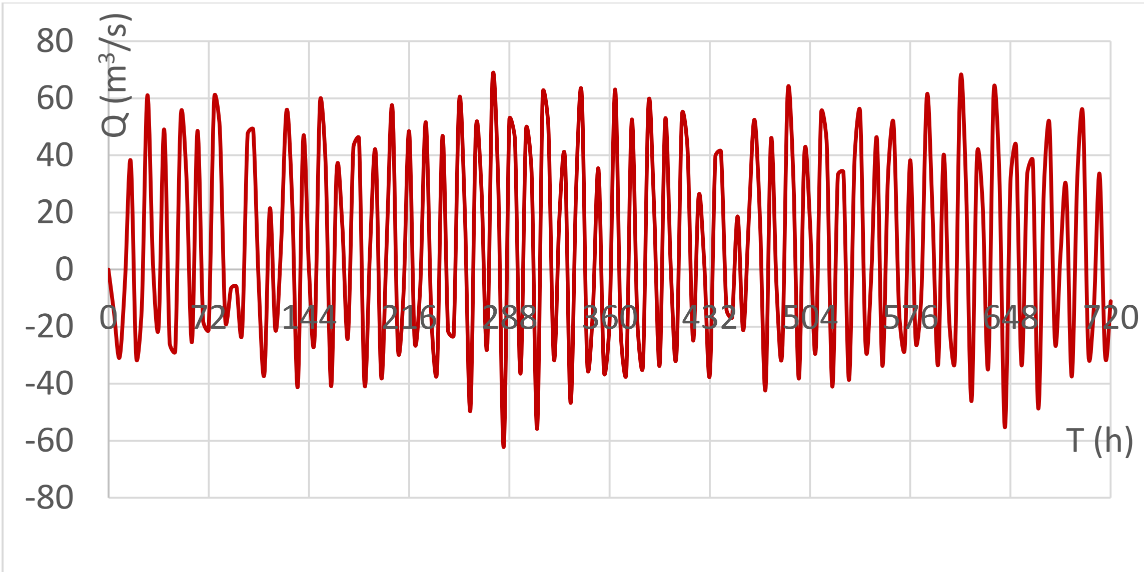

Figure 2.6: Discharge in Aug 2016 at Ong-Doc river

Sediment

Simulation of sediment transport in the area is considered as non-cohesive transport. The distribution of sand is assumed to be uniform throughout the study area. From the monitoring data of granular, the particle size is divided into four representative sizes: 0.06mm, 0.125mm, 1.0 mm, 1.5mm; with the initial rates of 40%, 30%, 20% and 10%.

The boundary conditions are:

- The open offshore boundary is free and balance condition.
- In the upstream areas, the boundary conditions are specified of Direclet type with the monitoring level.

The main parameters of simulation are as follows:

- The law of friction according to Nicuradse
- The bottom sediment transport model according to Soulsby - Van Rijn
- The settling velocity is determined by the Van Rijn, depending on the characteristic of the sediment layer.
- The value of the Shield taken by the Rijn Valves depends on the dimensionless dimension of the sediment classe.

3. Simulation of sediment transport

Simulations are made for two representative seasons: the southwest monsoon season and the northeast monsoon season. Each simulation season lasts for 2 months:

- West-South monsoon season: 8-9 / 2016
- East - North monsoon season: 2-3 / 2016

To assess the role of waves in erosion and accretion, simulations were performed for two cases: with and without waves. The results of sediment transport are determined from the combination of three equations, including hydrodynamics, waves, and morphological change. The sediment boundary at the sea is considered as a free zone for the movement of bed load and suspended sediment. Due to the limit of field data (bathymetry and sediments), this model only considers the confluences Bay Hap and Ong Doc. Concentration of suspended sediment is set at 100 mg / l.

Under the influence of the hydrological regime and U Minh coastal shores, satellite data for suspended sediments for the month were recorded as follows:

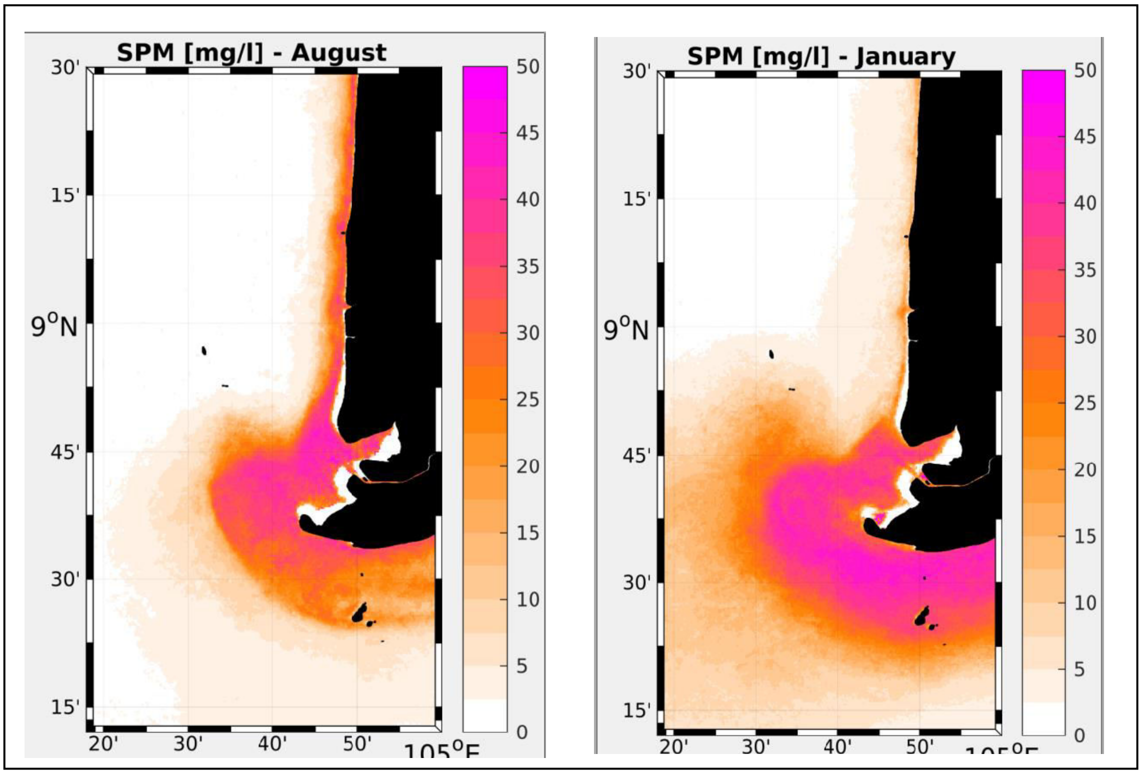

Figure 3.1: The typical average concentration of suspended sediment in August and Janurary from the satellite data

The above graph shows the effect of coastal waves on the concentration of suspended sediment in the area.

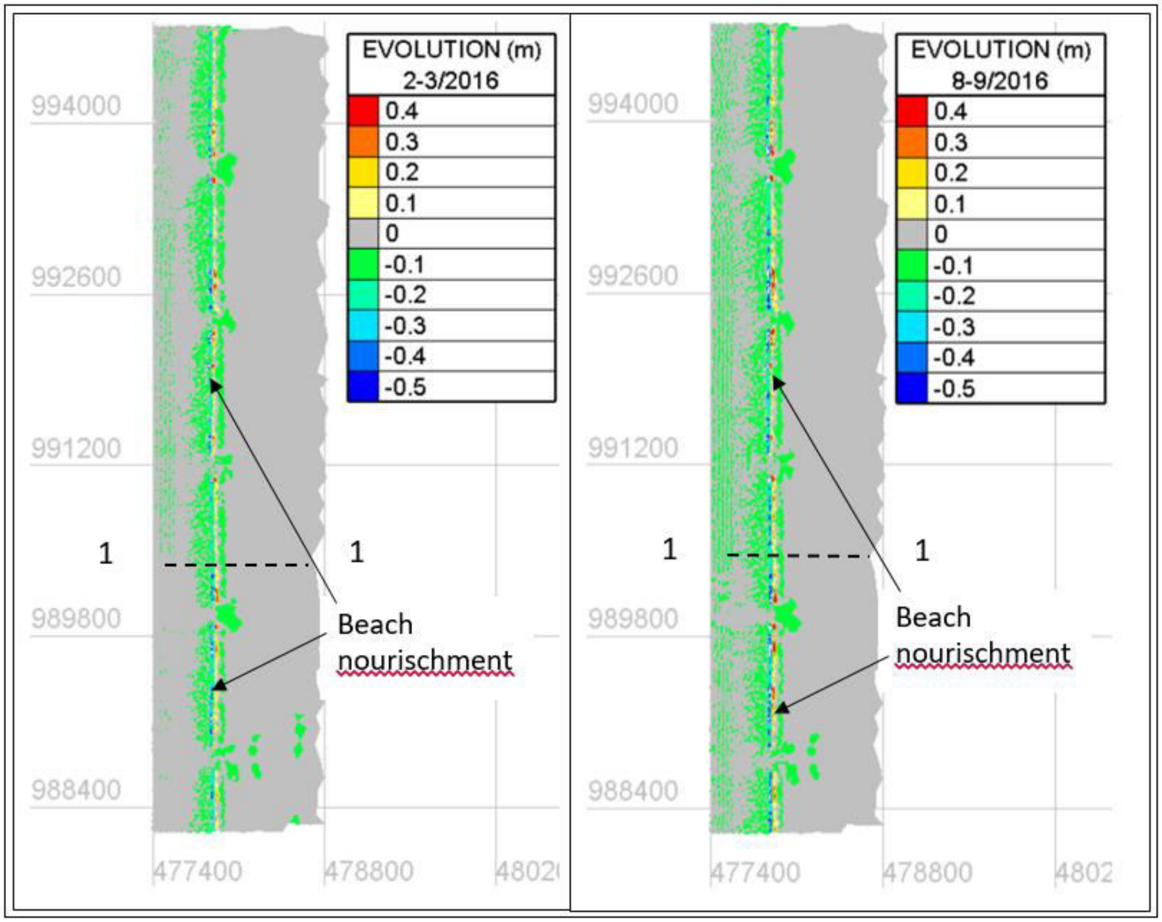

Figure 3.2: Erosion/accretion after 2 months: (a) 2-3/2016; (b) 8-9/2016 in case with beach nourishment (B=120m, Z=0.2m)

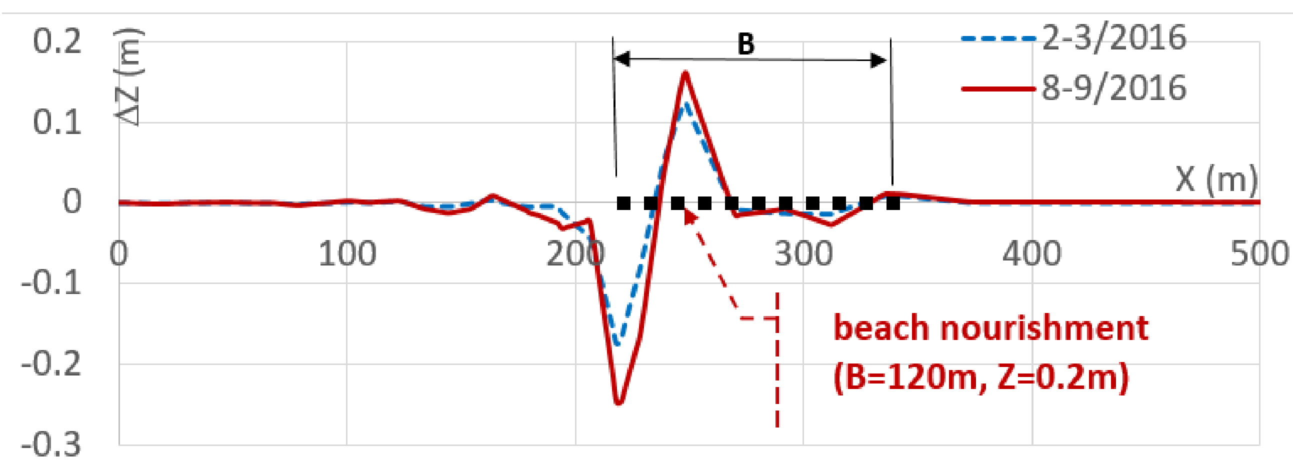

Figure 3.3: Accumulated evolution of bathymetry at section 1-1 in case with beach nourishment (B=120m, Z=0.2m). The continous line stands for 8-9/2016 and the dashed line stands for 2-3/2016.

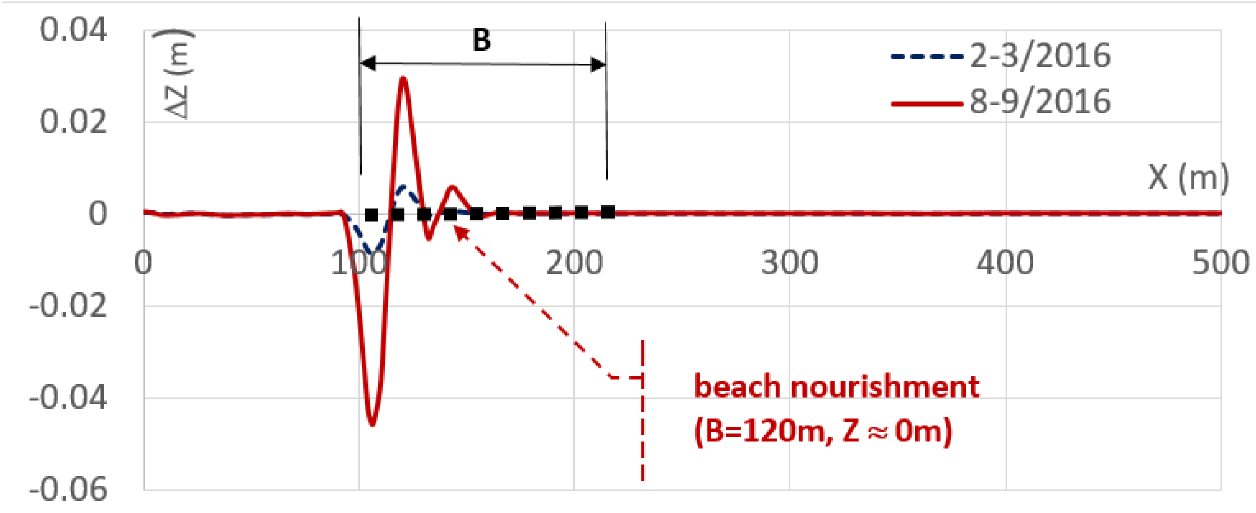

Figure 3.4: Accumulated evolution of bathymetry at section 1-1 in case with beach nourishment (B=120m, Z=0m). The continuous line stands for 8-9/2016 and the dashed line stands for 2-3/2016.

Comments:

- The erosion in 8-9 / 2016 has a slightly higher erosion in compared to 2-3 / 2016.
- There is local erosion at the head of the beach nourishment and accretion immediately after.
- There is more erosion/accretion at the head of the beach nourishment when the height of beach is higher. This phenomenon can be explained by the greater dissipation of wave energy at this location when elevations of beach nourishment is higher.
- There is a slight erosion occurring at the gap between two beach nourishment in the case of intermittent beach type.

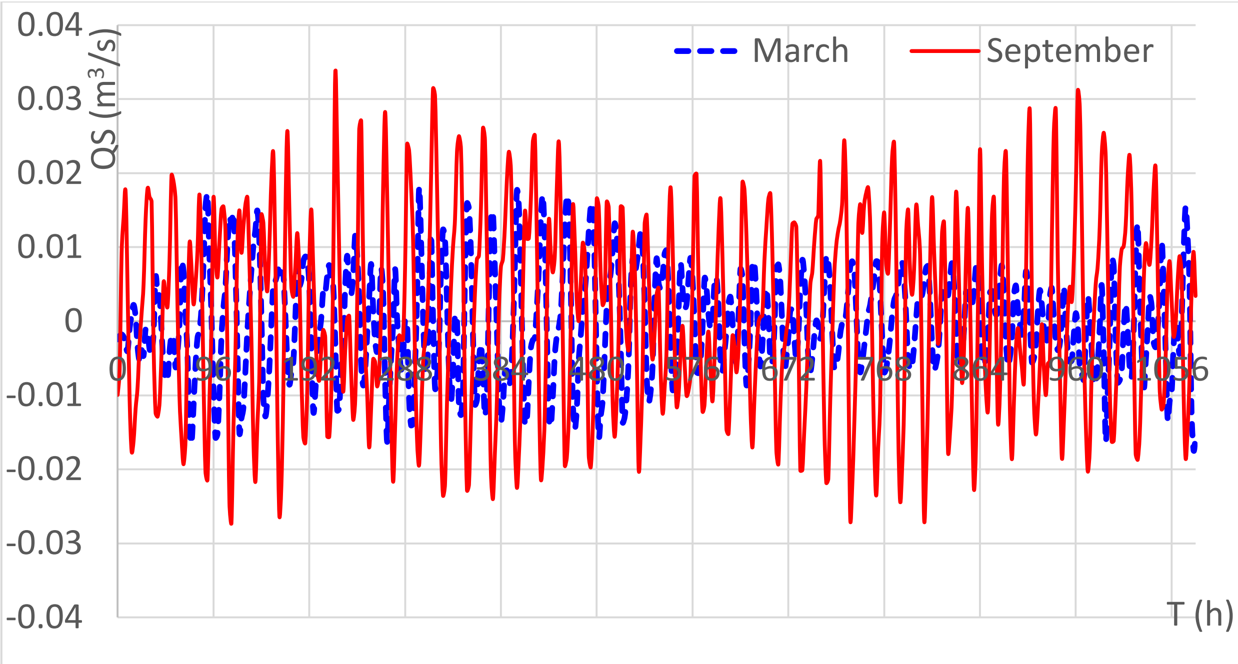

Figure 3.5: Sediment fluxes through cross section 1-1 over time in case

with beach nourishment.

(+: towards the north, - : towards the south)

Table 3.1: Sediment fluxes through cross section 1-1 in case with beach nourishment

	Sum (m^3)	Notes
From 15/2/2016 to 31/3/2016	-654.5	(+) : towards the north
From 15/8/2016 to 30/9/2016	4875.7	(-) : towards the south

Comments:

- Fluxes through cross section 1-1 over time in case without measure are higher slightly than the fluxes in case with beach nourishment. This result can be explained by the concentration of sediment suspended in the area between the beach nourishment and the coast is smaller than in the case of without measure.

In order to quantify the sediment transport within the BN area, the sediment budget analysis in typical area of B=800m in width and L=7000m in length will be conducted (see Figure 3.2).

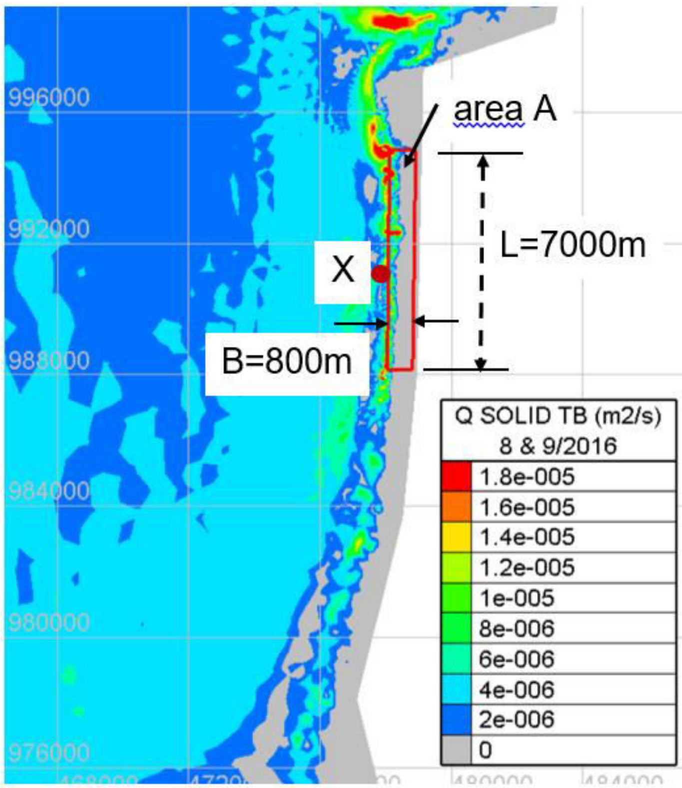

Figure 3.2: Area for sediment budget analysis

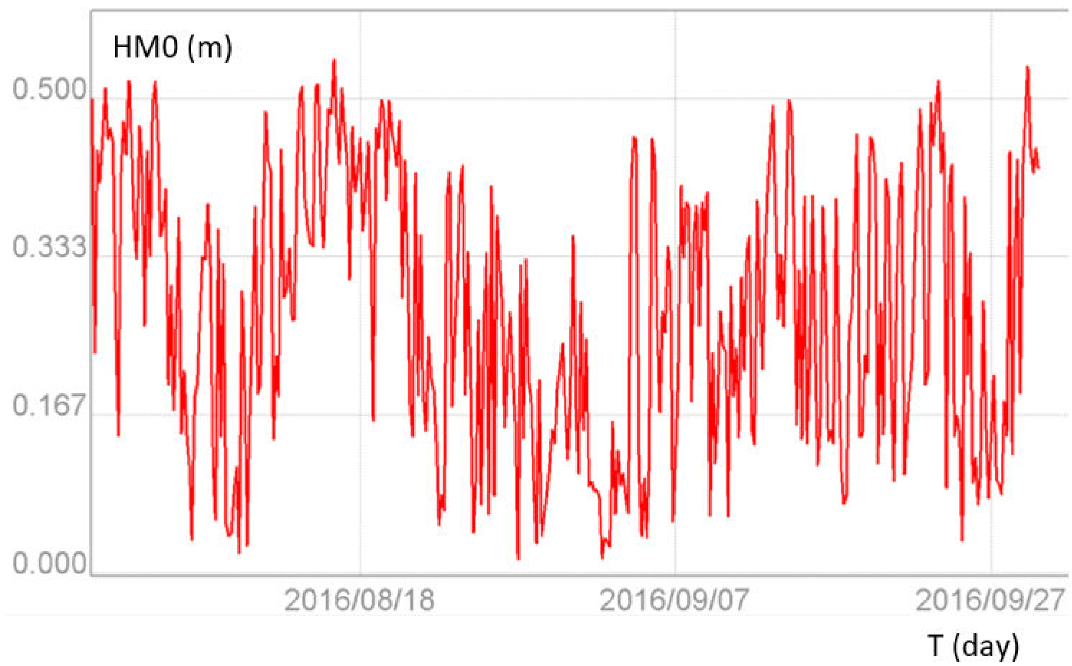

Figure 3.3: Wave height HM0 (m) at typical location X in 8-9/2016

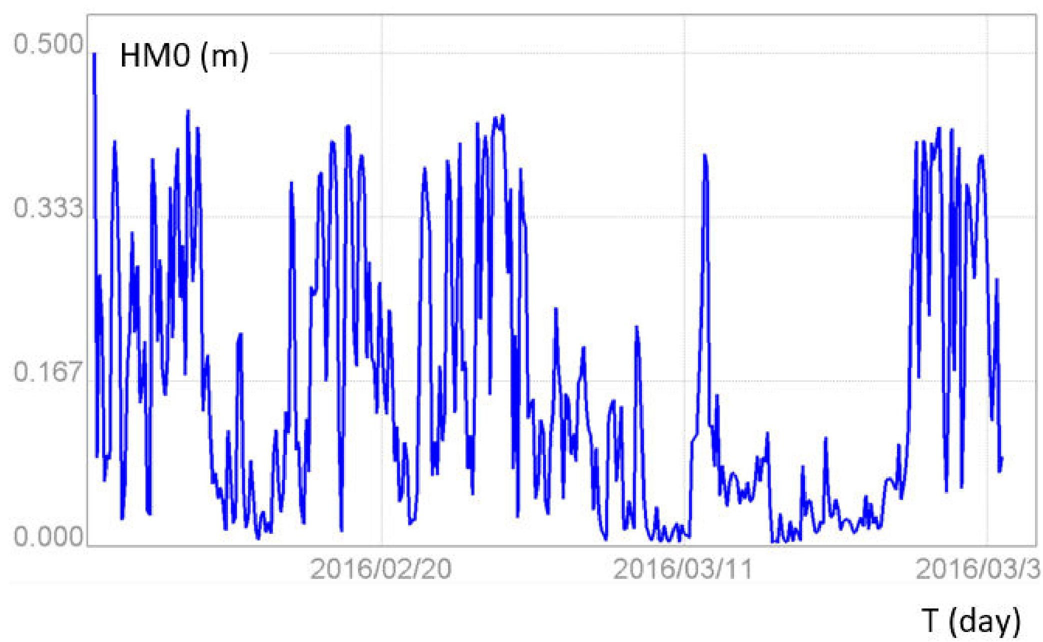

Figure 3.4: Wave height HM0 (m) at typical location X in 2-3/2016

The results in Figures 3.3 and 3.4 show that waves in the Feb – Mar.. 2016 period are larger than those in Aug. - Sep. 2016 at the X location. This relates to the intensity of the corresponding winds during this period.

The following results compare the erosion behavior in the A area (Figure 3.2) for two cases with and without BN.

Table 3.1: Sediment budget analysis in 8-9/2016

Cases	In (m^3)	Out (m^3)	(In - Out) m^3	Comment
Without BN	94.1	242.3	-148.2	(+) accretion ; (-) erosion
BN with B=60m, L=7000m, H=1.7m (Z= - 0.4m)	90.6	137.8	-47.2	
BN with B=120m, L=7000m, H=1.7m (Z= - 0.4m)	108.2	5.8	102.4	
BN with B=120m, 7xL1=7000m, Z=+0.2m	886.2	7.4	878.8	

Table 3.2: Sediment budget analysis in 2-3/2016

Cases	In (m^3)	Out (m^3)	(In - Out) m^3	Comment
Without BN	302.7	375.8	-73.1	(+) accretion ; (-) erosion
BN with B=60m, L=7000m, H=1.7m (Z=-0.4m)	291.5	245	46.5	
BN with B=120m, L=7000m, H=1.7m (Z=-0.4m)	314.5	11.2	303.3	
BN with B=120m, 7xL1=7000m, Z=+0.2m	1763.9	17.1	1746.8	

Comment:

- The BN can reduce the erosion in the shore area behind. The erosion decreases as the width of the nourishment increases (compare B = 60m and B = 120m). This result is explained by the effect of reducing the wave energy of the larger B site and thereby mitigating part of the erosion factor.
- The coastal erosion in Aug-Sep 2016 is larger than in Feb – Mar. 2016. This result is closely correlated with the corresponding wave intensity at this times.

4. CONCLUSION:

Simulations have been made with the BN solution to prevent erosion of the protected area. The simulation results of sediment transport in U-Minh coastal areas in two representative periods (2-3/2016 and 8-9/2016), considering wave effect showed the following main results:

- Waves are an important cause of erosion in the U-Minh coast.
- BN has the effect of reducing coastal waves, thereby reducing the phenomenon of coastal erosion.
- Larger BN is more effective.
- The elevation BN being about 0.2m (minimum sea level + 0.5m) seems reasonable to dissipate the energy waves going to shore.

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