

## MIKE 21/3 Coupled Model FM

### Shoreline Morphology Module

#### Step-by-step training guide – Headland Beach example



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## 1 Introduction

This document contains a step-by-step guide for setting up and running DHI's MIKE 21/3 Coupled Model FM Shoreline Morphology for the Headland Beach Example. All files needed to run the guide are located in the folder HeadlandBeach. Before starting working on the example, copy the entire folder to your local user directory.

The example is concerned with investigating different mitigation options for a section of a headland beach shown in Figure 1.1.

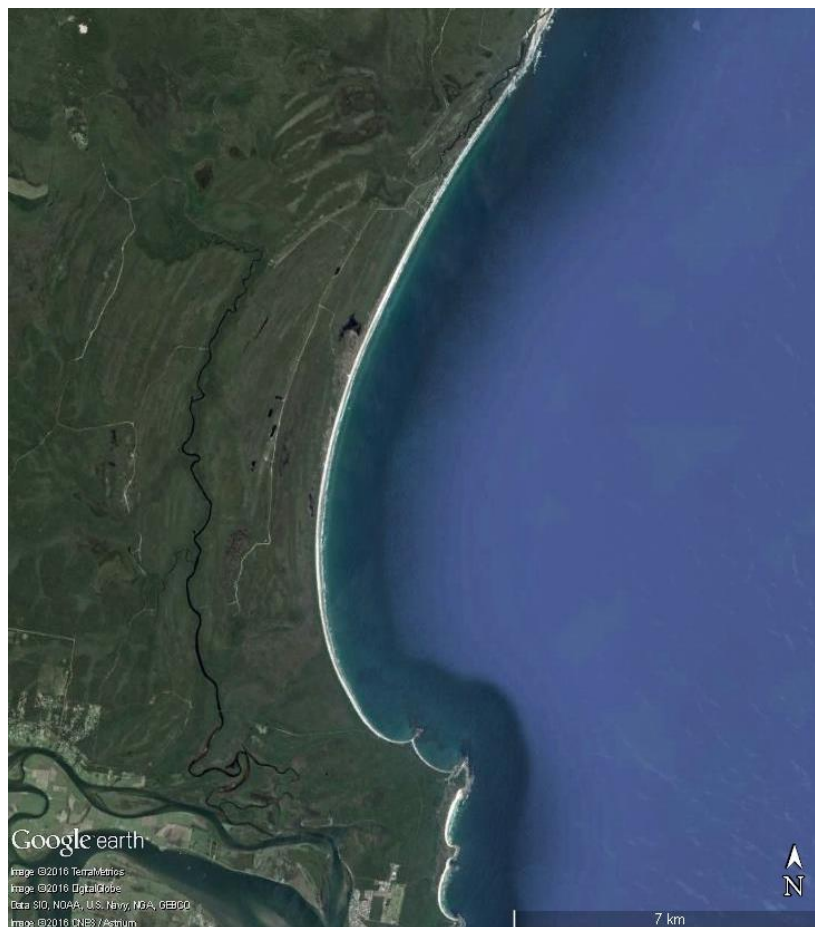


Figure 1.1 The headland beach studied in the present example

As this is not a real case, a synthetic bathymetry has been created and is provided in the mesh file which is part of the example. The bathymetry is shown in Figure 1.2 which also shows the mesh resolution. The section of shoreline which we will be looking at in this example is covered by the finest mesh resolution in the nearshore area.

The longshore sediment transport along this shoreline is assumed to be driven by waves only, i.e. tidal currents and surface elevations are ignored.

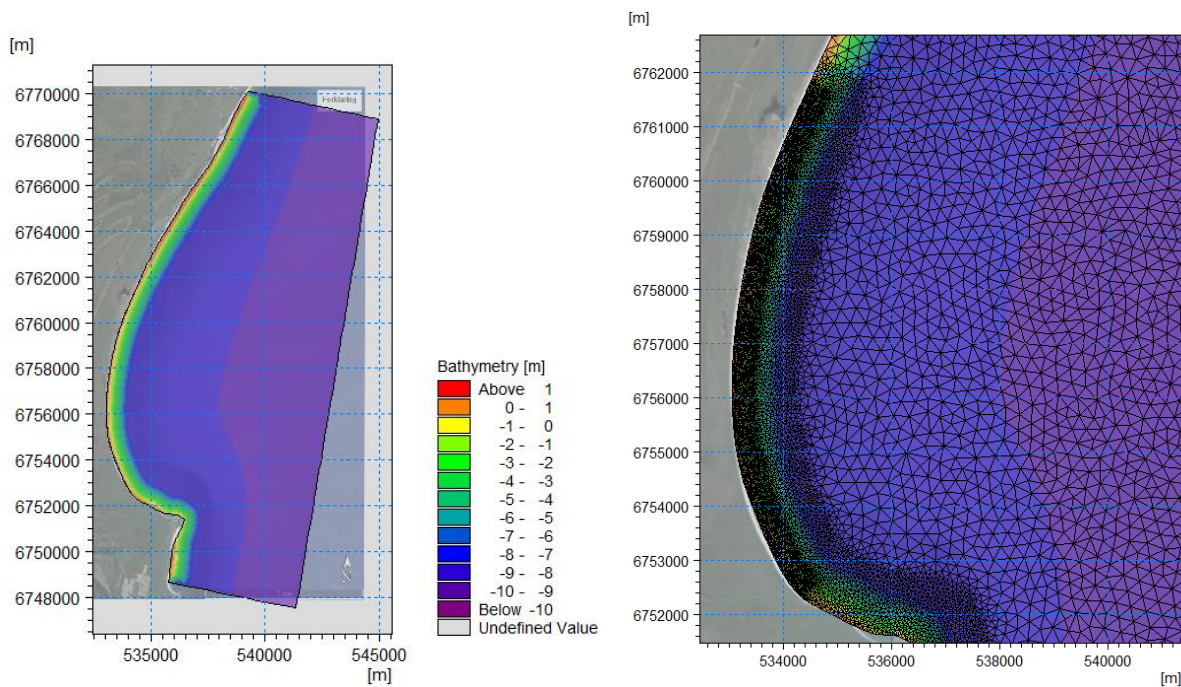


Figure 1.2 The synthetic bathymetry (left) together with the mesh resolution in area of interest (right)

The following files are part of this example:

- HeadlandBeach.mesh
- stokes\_5\_d50\_0.18\_sigma\_1.3\_no\_ripples.lon
- stokes\_5\_d50\_0.18\_sigma\_1.3\_no\_ripples.crs
- HeadlandBeach\_standard\_morphology.mfm
- HeadlandBeach\_shoreline\_morphology.mfm
- HeadlandBeach\_shoreline\_morphology\_baseline.mfm
- HeadlandBeach\_shoreline\_morphology\_breakwater.mfm
- HeadlandBeach\_shoreline\_morphology\_groyne.mfm
- HeadlandBeach\_shoreline\_morphology\_headland.mfm
- make\_shoreline\_inputs.mdf
- baseline.xyz
- coastline.xyz
- edgemap.dfsu
- profile\_cld\_8\_dune\_1.xyz
- coastline\_warmed\_up.dfs1
- breakwater\_points.xyz

## 2 Setup and Run the MIKE 21 Sand Transport FM Model

This guide assumes that you are familiar with setting up a standard coupled MIKE 21 Sand Transport FM Model. If you are not familiar with this, please refer to the step by step guide, which can be accessed via the MIKE Zero Documentation Index in the start menu:

[MIKE 21/3 Coupled Model FM, Step-by-Step Training Guide: Coastal Application](#)

Our starting point in this guide is therefore that a standard coupled MIKE 21 Sand Transport FM Model has been setup, so open and check that you can run the file HeadlandBeach\_standard\_morphology.mfm.

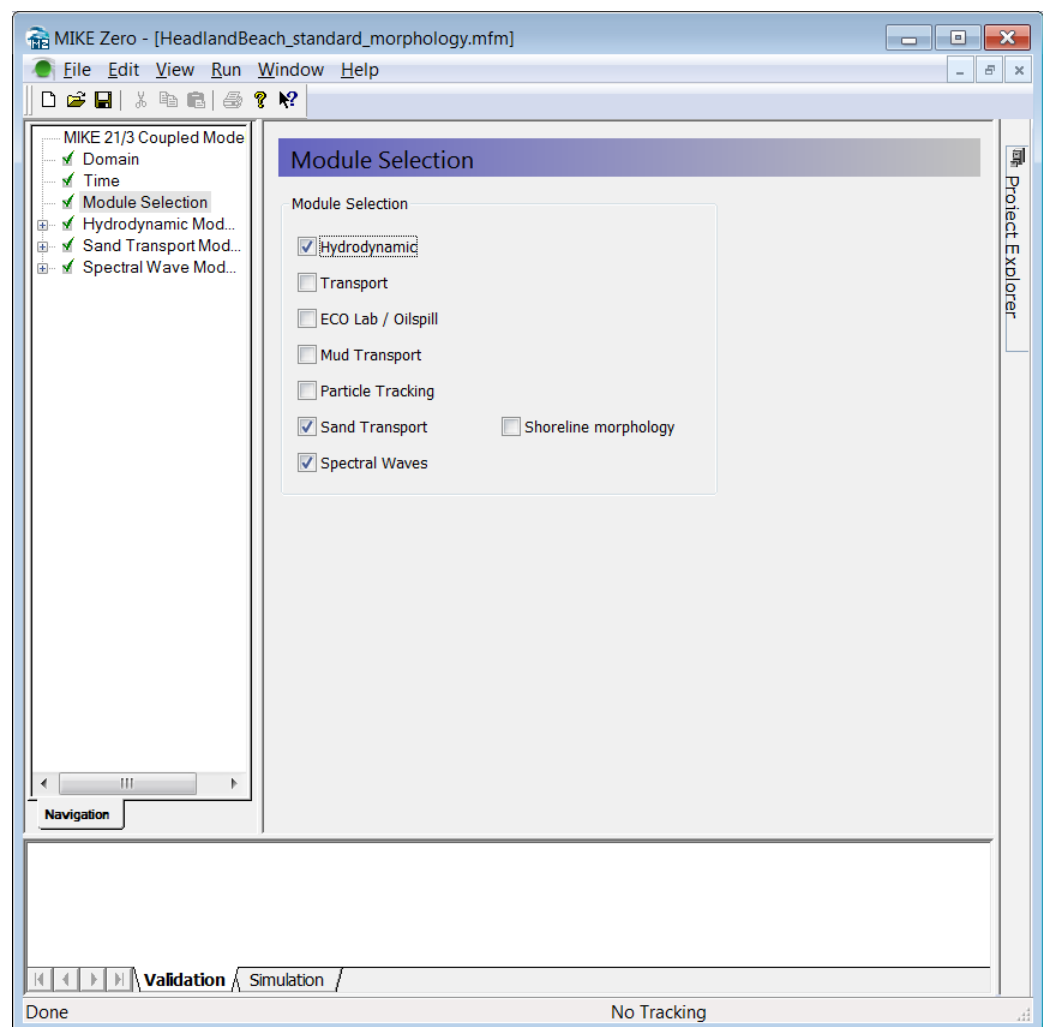


Figure 2.1 Impact of breakwater default morphology

Have a look at how the model has been setup; especially note that the HD model is run in quasi-stationary mode as shown in Figure 2.2; other important setup parameters are listed in Table 2.1.

Running this model will take some time and we will not use the results for anything as we are focused on the Shoreline Morphology model, so either stop the model simulation, or while it is running, move on to the Shoreline Morphology model in the next section.

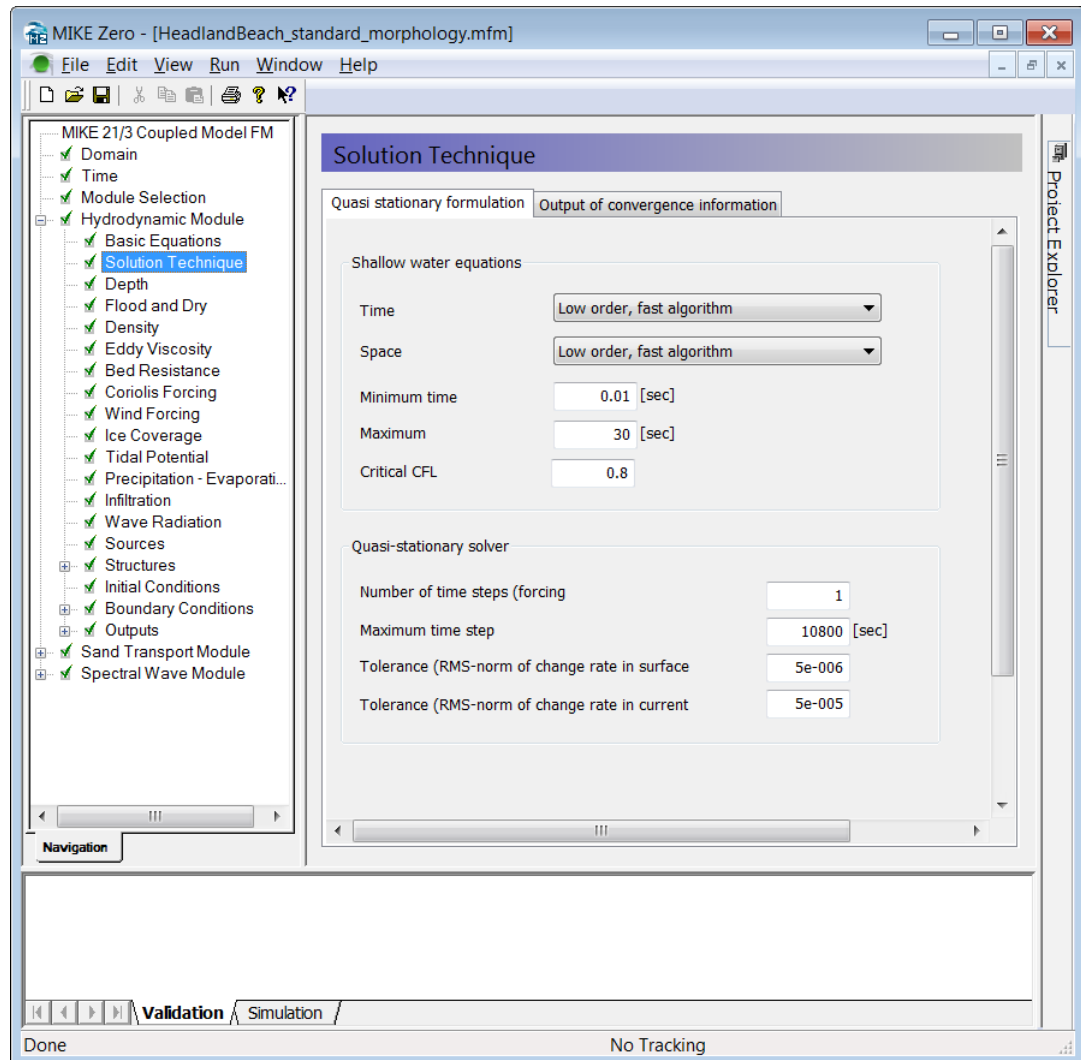


Figure 2.2 Quasi steady HD solver is used



Table 2.1 Parameters used in the standard setup of the couple HD, SW and ST model  
 (continued on next page)

Hydrodynamic Module	
Basic Equations	Quasi stationary formulation
Solution technique	<i>Shallow water equations</i> Time integration/Space discretisation: Low order fast algorithm <i>Quasi-stationary solver</i> Maximum time step interval: 10800 s Tolerance (RMS-norm dh/dt): 5e-006 Tolerance (RMS-norm duv/dt): 5e-005
Flood and dry	Default values
Eddy viscosity	Smagorinsky with default value
Bed resistance	Manning = 32 m <sup>1/3</sup> /s
Coriolis Forcing, Wind, Ice, Tidal Potential, Precipitation, Infiltration	Excluded
Wave Radiation	Type: Wave radiation from SW simulation
Boundary conditions	East: Land boundary (zero Normal velocity) South: Land boundary (zero Normal velocity) North: Land boundary (zero Normal velocity)
Sand Transport Module	
Model Definition	Sediment transport table: stokes_5_d50_0.18_sigma_1.3_no_ripples.lon
Sediment properties	Median grain size 0.18 mm Grading coefficient: 1.3
Forcings - Waves	Type: Wave field from SW simulation
Morphology - General	Max bed level change: 10m/day Speedup factor 1 Include feedback on HD, SW and ST: True
Spectral Wave Module	
Basic Equations	<i>Spectral formulation:</i> Directionally decoupled parametric formulation <i>Time formulation:</i> Quasi stationary formulation
Spectral Discretisation	<i>Directional Discretisation:</i> Number of directions: 16

Spectral Wave Module cont'd:	
Solution technique	<i>Shallow water equations</i> Time integration/Space discretisation: Low order fast algorithm <i>Quasi-stationary solver</i> Maximum number of iterations: 50 Tolerance (RMS-norm of residual): 1e-5 Tolerance (max-norm of $\Delta H_s$ ): 1e-2
Water Level Conditions	Type: Water level variation from HD simulation
Current Conditions	From HD simulation
Wind, ice, diffraction	Excluded
Wave Breaking	Specified gamma default values
Bottom Friction	Nikuradse roughness $k_n = 0.01$ m, include effect on mean frequency
Boundary conditions	South: Lateral boundary East: $H_s = 2.5$ m, $T_p = 12$ s, MWD = 140, DSI = 10 North: Lateral boundary

### 3 Initial Look at the Shoreline Morphology Model

Open the file HeadlandBeach\_shoreline\_morphology.mfm. The Shoreline Morphology model is activated by selecting it on the module selection panel as shown in Figure 3.1. It is only possible to select the Shoreline Morphology if both the HD, SW and ST modules are selected.

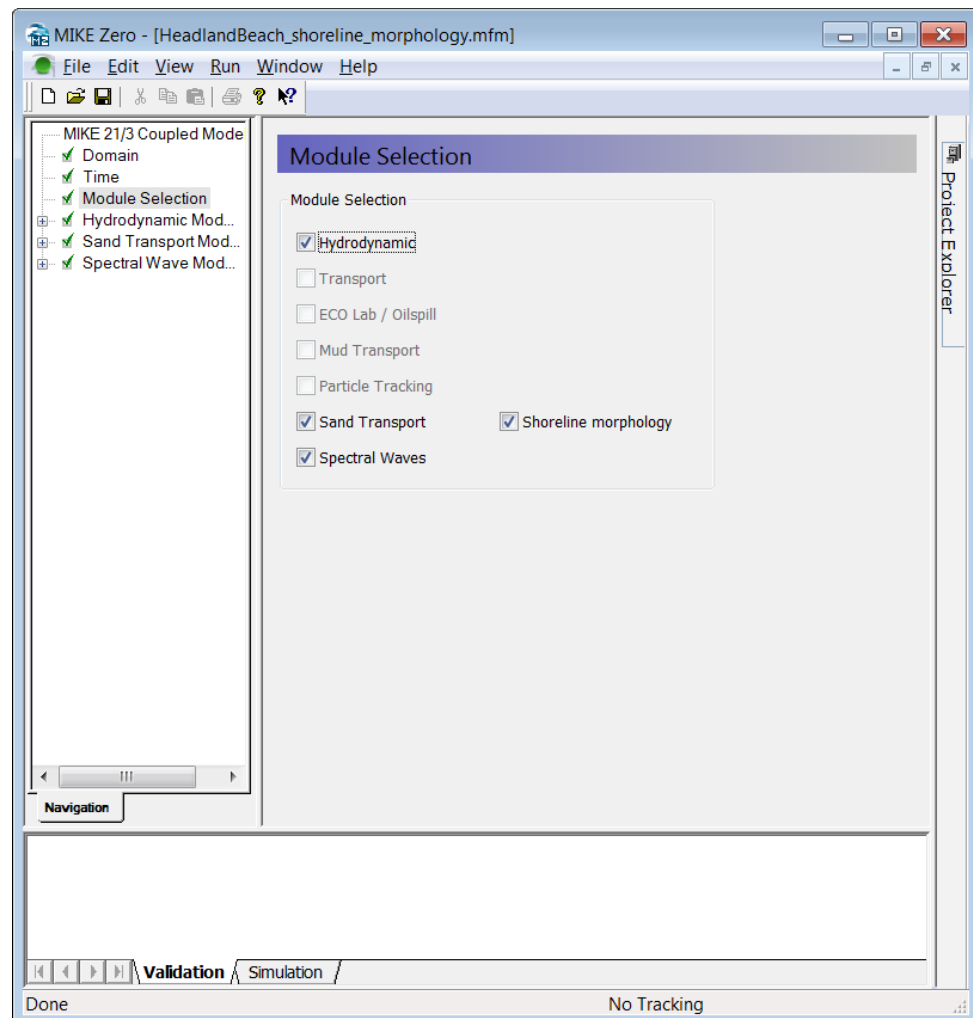


Figure 3.1 Module selection

The Shoreline Morphology model lives inside the *Morphology* section of the *Sand Transport Module*. When selecting *Shoreline model* an overview of the mesh and the Shoreline Morphology model inputs are shown graphically on the input pane as shown in Figure 3.2; it is possible to zoom in the figure or change the background to either show the mesh, the bathymetry or the edge map (default).

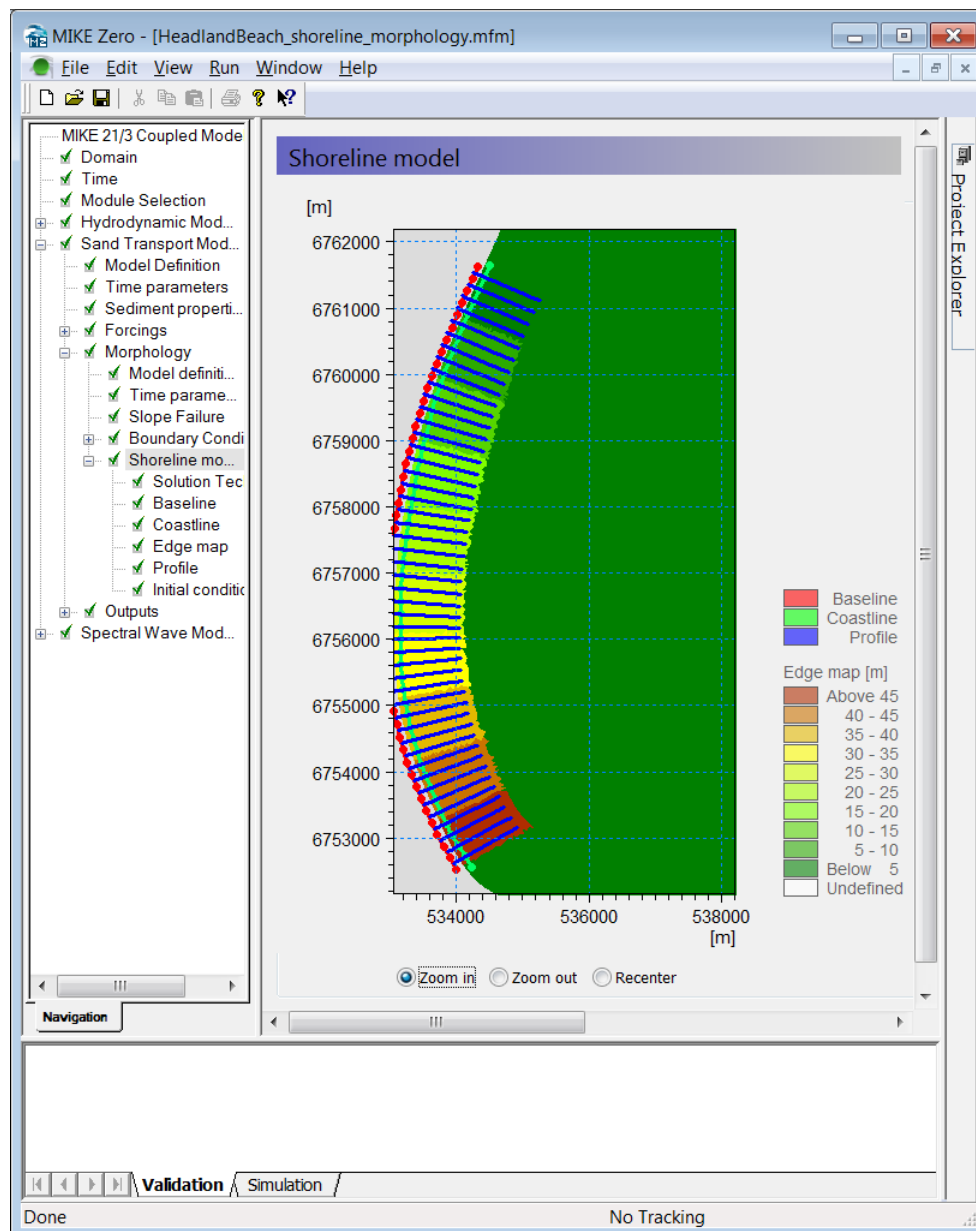


Figure 3.2 Overview of the *Shoreline model*

As seen in Figure 3.2, there are 6 subsections to the *Shoreline model* where we need to select inputs for the Shoreline Morphology model, but first we need to generate the inputs for the model, namely the *Baseline*, the *Coastline*, the *Edge map* and the *Profile*. These inputs can all be generated using a new tool in the *Mesh Generator* based on a mesh file. This is what we will do in the next section. If you just want to get started running the model using the supplied inputs, you can go straight to section 5.

## 4 Creating input files for the Shoreline Morphology Model

All input files for the *Shoreline model* will be generated using the Mike Zero Mesh Generator. A new tool is available in the “Shoreline” menu shown in Figure 4.1.

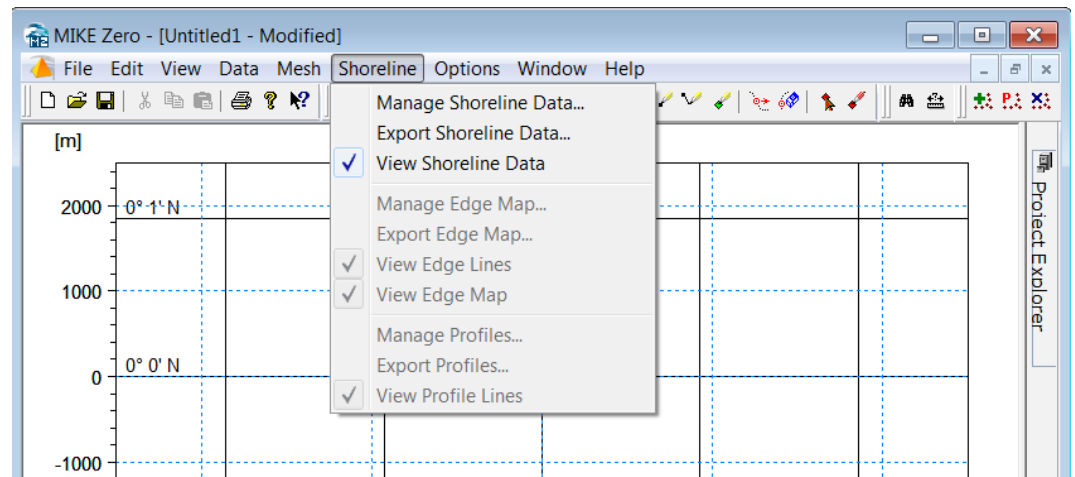


Figure 4.1 Shoreline menu in Mesh Generator

### 4.1 Step 1: Load Mesh

First we load the mesh (use the projection: MGA-56) which we would like to use in our simulation and enable arc editing as shown in Figure 4.2. Load in the mesh *HeadlandBeach.mesh*.

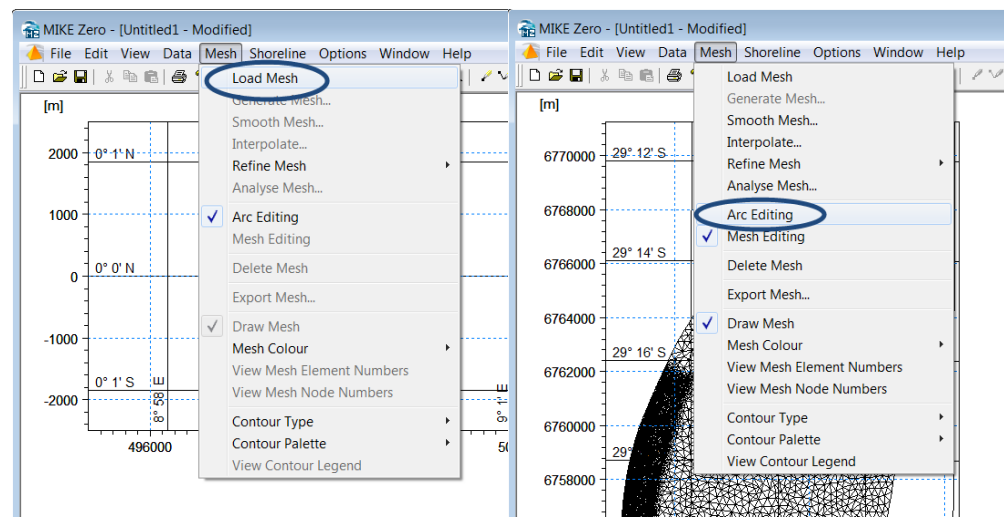


Figure 4.2 Load mesh and enable Arc Editing

## 4.2 Step 2: Create Baseline

Looking at the mesh you can see that there is fine resolution in the nearshore area along our area of interest. Zoom into that area and use the arc tool to draw the baseline along the shoreline in our area of interest as shown in Figure 4.3. Make sure that you start on the left end of the shoreline when looking towards the sea, as shown with the red arrow in Figure 4.3.

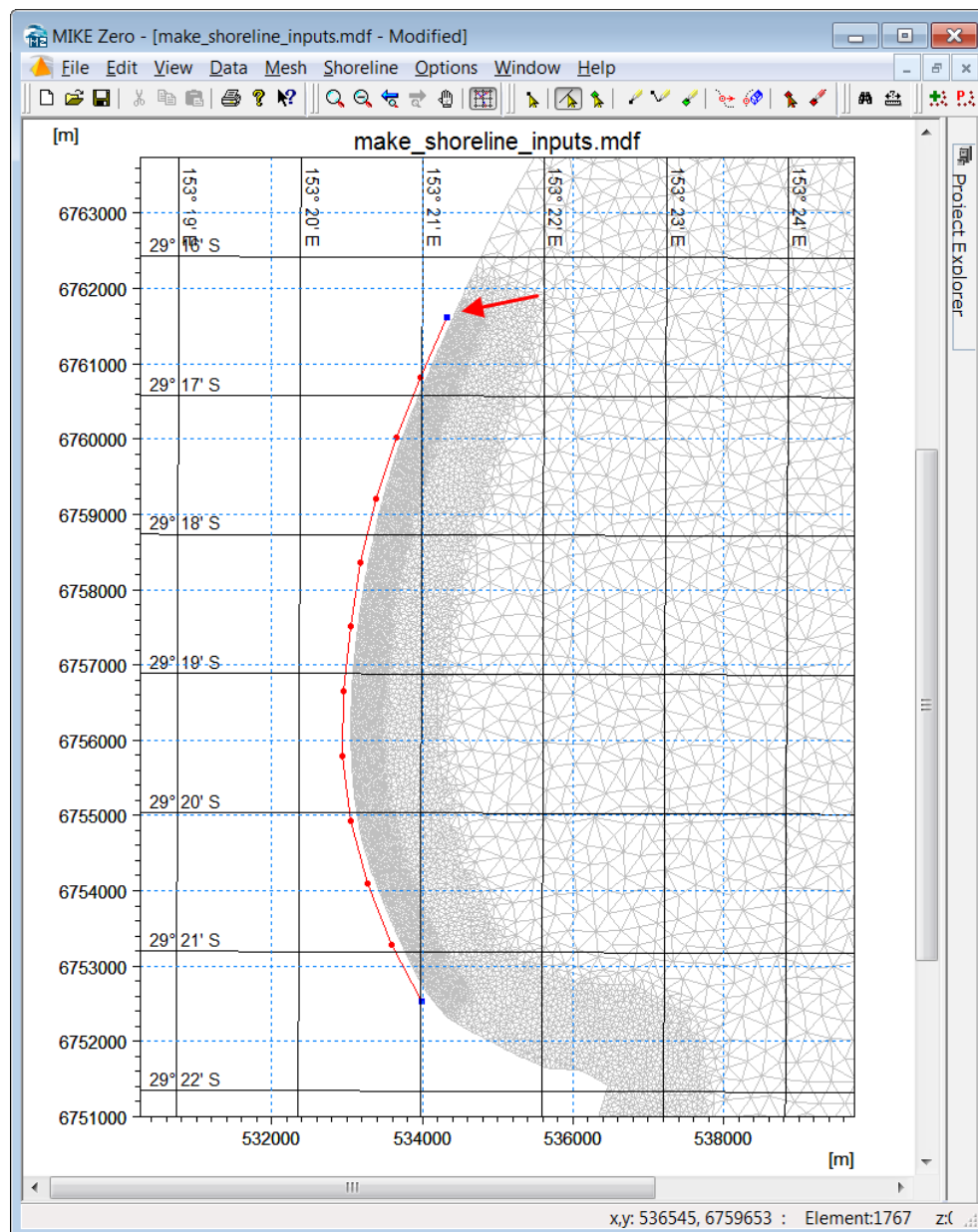


Figure 4.3 Drawing the baseline using the arc tool along the area of interest

Next, redistribute the number of vertices on the baseline to match the desired resolution of the shoreline points. This resolution must match with the mesh resolution in the nearshore area such that we have at least 3-4 mesh elements between adjacent baseline vertices. In Figure 4.5, 200 m between vertices was chosen together with a spline tension factor of 0.5 as shown in Figure 4.4.

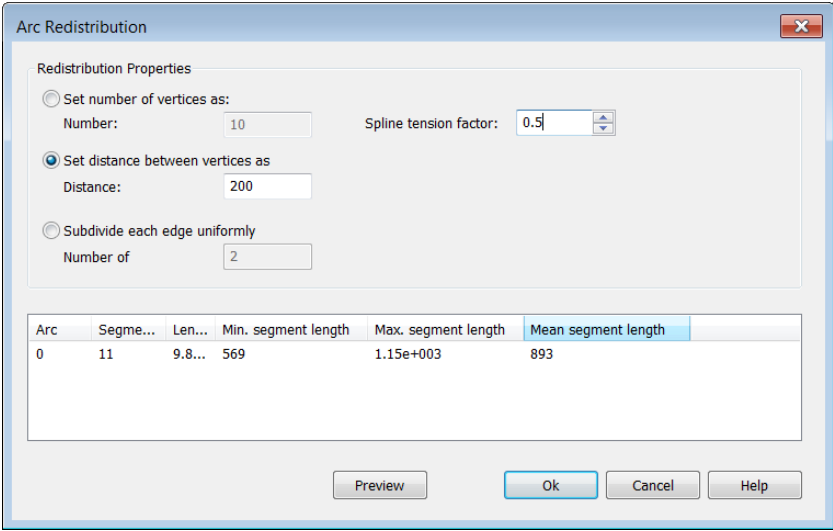


Figure 4.4 Redistribute vertices on baseline arc

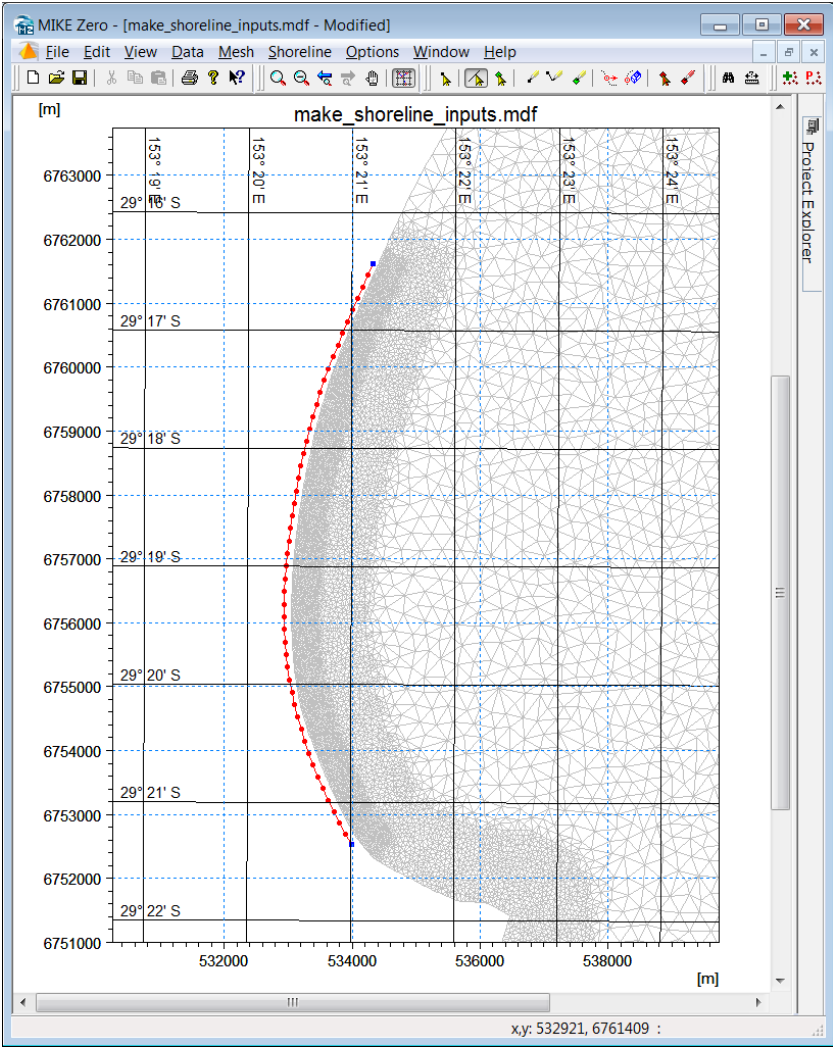


Figure 4.5 Baseline with redistributed vertices

Now the attributes of the baseline are set to 100 with the start node attribute set to 99 as shown in Figure 4.6.

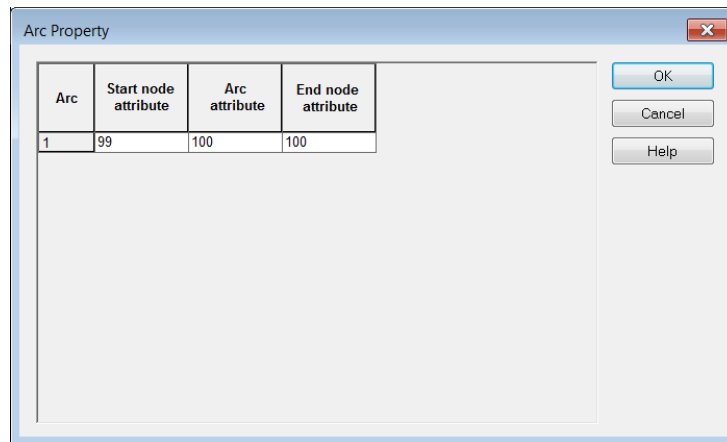


Figure 4.6 Setting the attributes of the baseline

### 4.3 Step 2: Create Initial Coastline

Now we are ready to create the initial coastline position. Again, we draw this as an arc using the arc tool. First turn on the depth contours of the mesh (Mesh->Contour type->Shaded contours); choose a colour palette that enables you to clearly see the 0 meter depth contour as shown in Figure 4.7 (use Mesh -> Contour Palette -> New). Start drawing the coastline arc from the left end of the shoreline when looking towards the sea (shown with the red arrow) and make sure your first point and last nodes are outside the first and last nodes of the baseline arc.

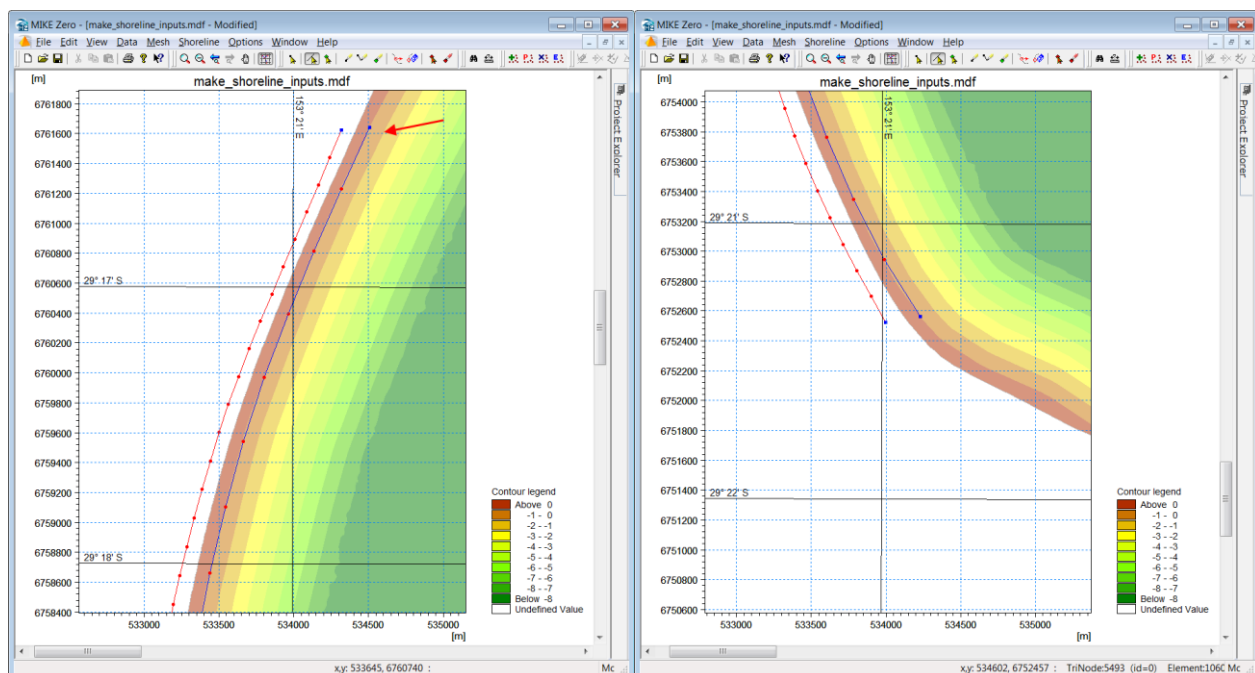


Figure 4.7 Creating initial coastline with first and last point outside the range of the baseline



The number of vertices on the coastline is not important as we will use a tool to make it match correctly to the number of points on the baseline. First set the attributes of the coastline to 110 (with the start node attribute set to 109) as shown in Figure 4.8.

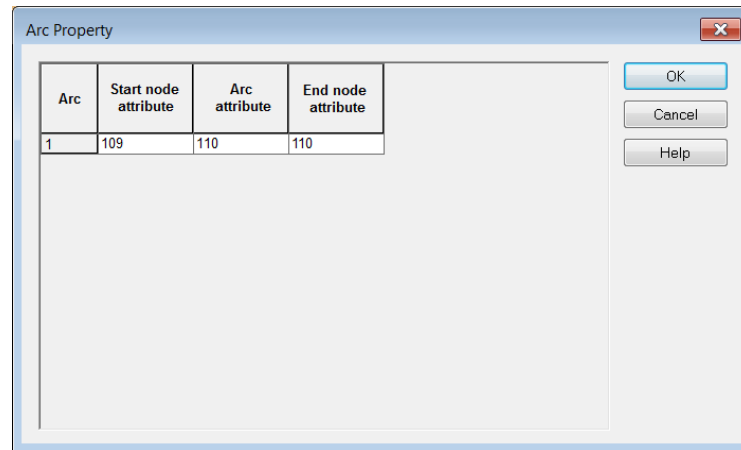


Figure 4.8 Setting the attribute of the coastline arc

Now select *Manage Shoreline Data* from the *Shoreline* menu as shown in Figure 4.9. Set the attribute of the baseline and coastline to the values chosen for the respective arcs and press *Modify coastline arc*.

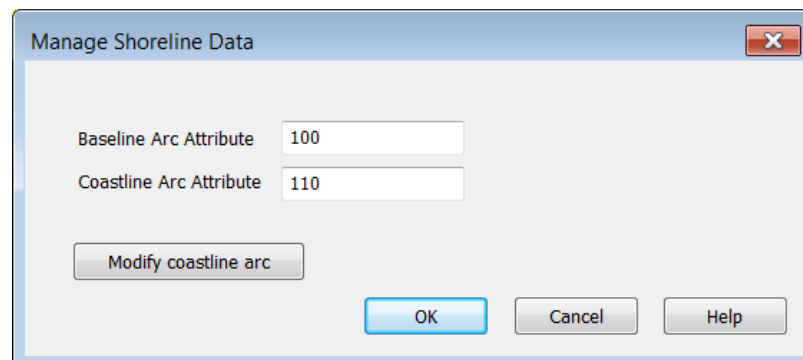


Figure 4.9 Manage shoreline data

Your coastline arc should now have the correct number of points, i.e. one more point than the baseline. Note that the first and the last point on the coastline are only used for boundary condition purposes in the Shoreline Morphology model. The boundary condition is zero gradient in the transport over the boundary which means that the orientation of the first and last shoreline segment does not change during the simulation; thus setting it to something reasonable to begin with is recommended. Here, in our simple example it is easy.

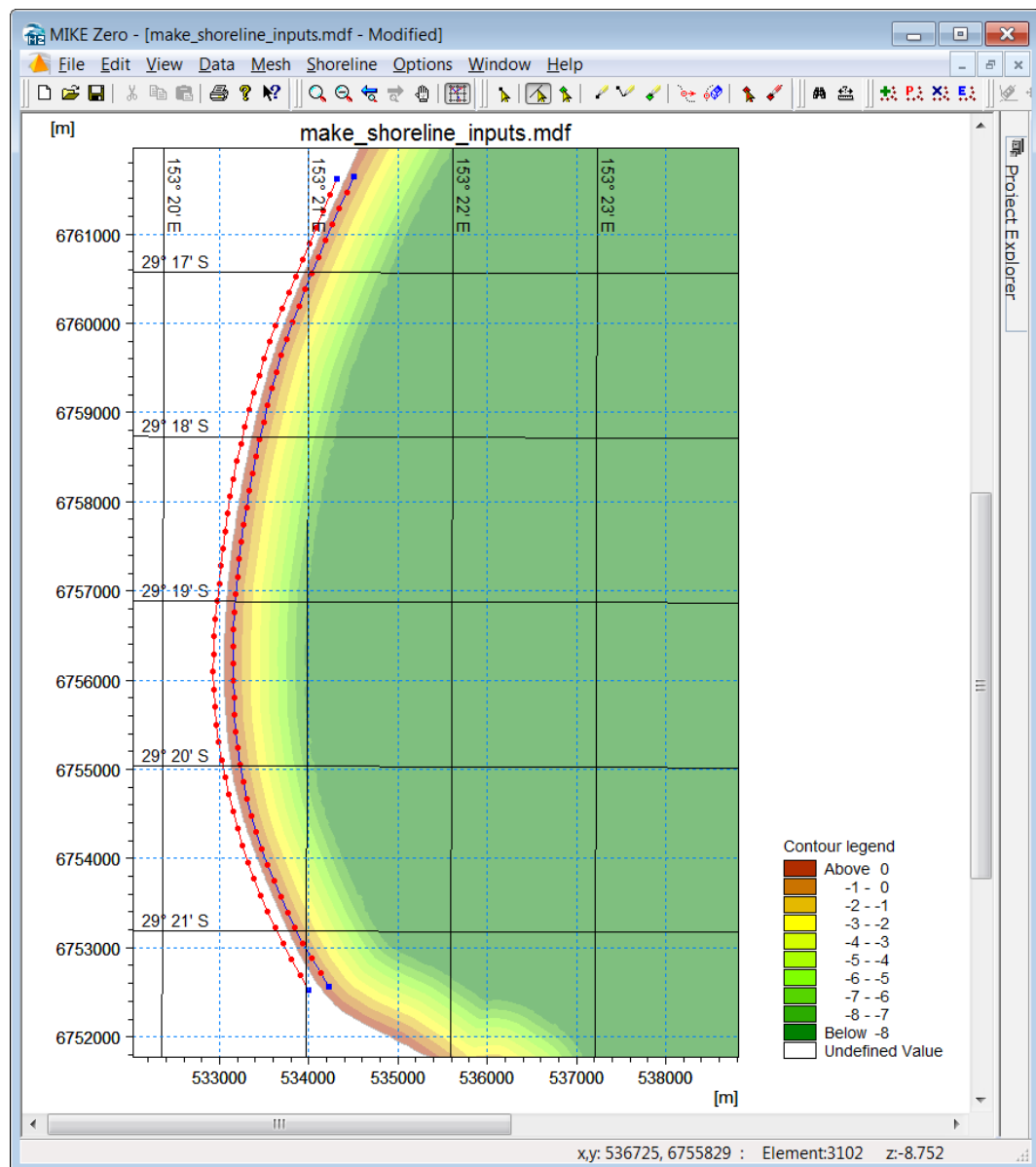


Figure 4.10 Modified coastline arc

Now we are ready to save our baseline and coastline. Select *Export shoreline data* from the Shoreline menu and select the location of the baseline and coastline before pressing Ok, see Figure 4.11.

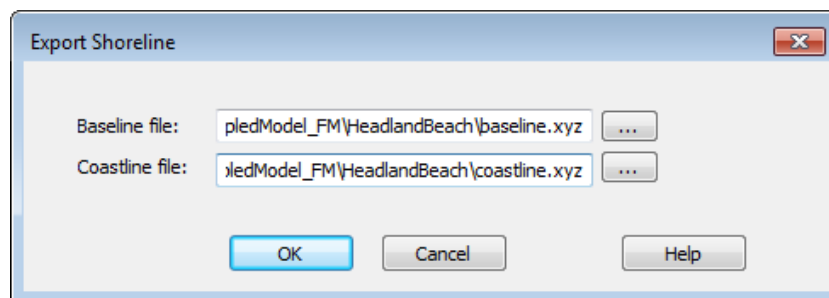


Figure 4.11 Export shoreline data

It is a good idea to add the node number as the fourth column in the baseline.xyz file. This can be done using excel combined with an advanced text editor as shown in Figure 4.12. By doing this we can load in the node number on top of 2D results files in the Data Viewer this makes it easier to see where in the 2D results our baseline/coastline results are located.

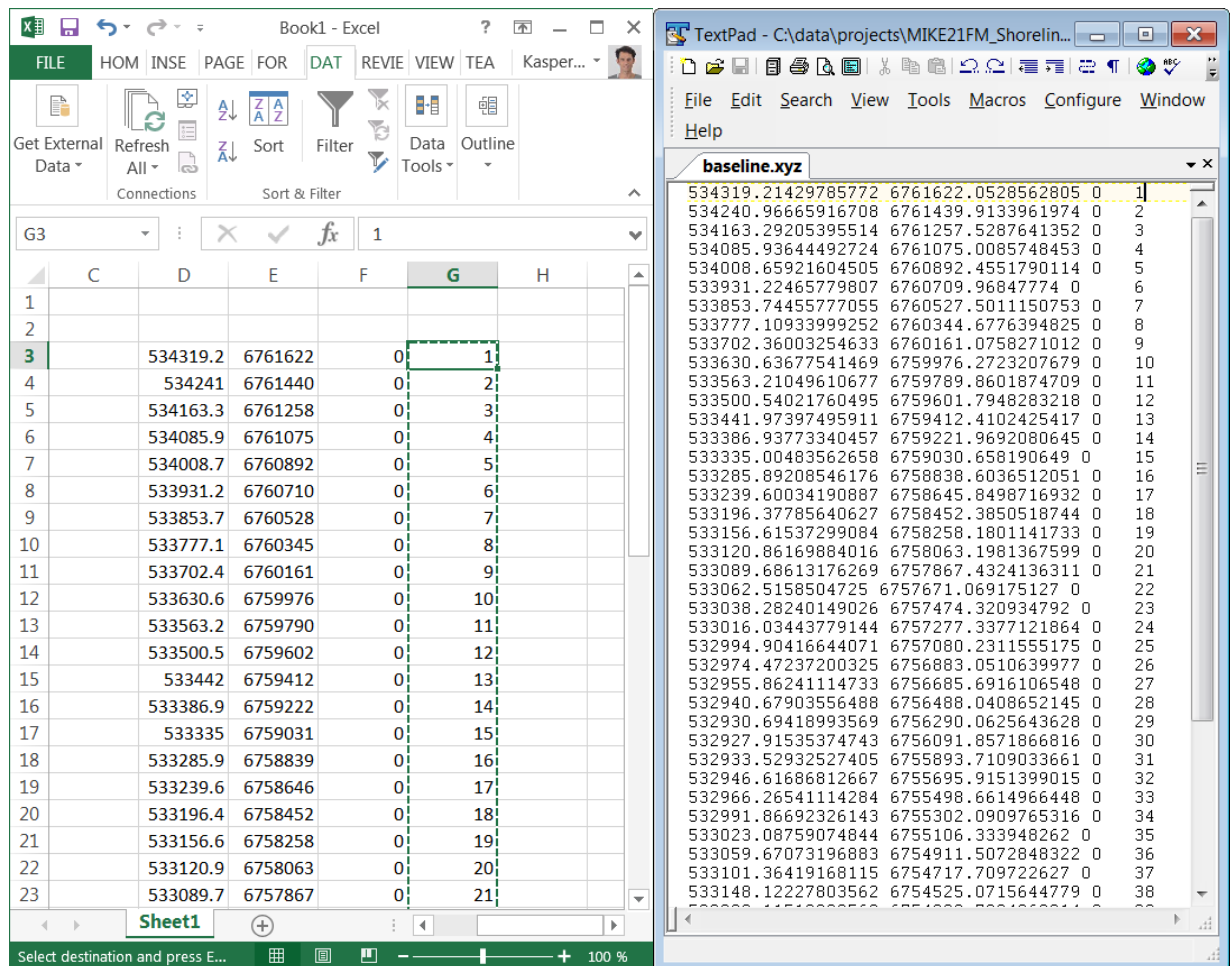


Figure 4.12 Add the baseline node number as the fourth column in the baseline.xyz file

## 4.4 Create Edge Map

Now we would like to create our edge map. To do so we first need to create an arc defining the offshore boundary of the map. The values in the edge map will be calculated between the baseline and this offshore arc; outside this defined area the map values are zero and the shoreline morphology will not be active. The off-shore arc should be located further offshore than the depth of closure, but close enough to shore so that the normals to the baseline segments do not cross each other; for highly curving shorelines there is a trade-off where the depth of closure in the model is limited by the curvature. Furthermore, the mesh resolution must be relatively fine in the area, but it can be coarser than in the nearshore area as we do not expect wave breaking in this area. In the present case we will locate it beyond the 8 m contour as shown in Figure 4.13 just inside the fine (but not finest) mesh resolution. Then the attribute of this arc is set to 120, see Figure 4.15.

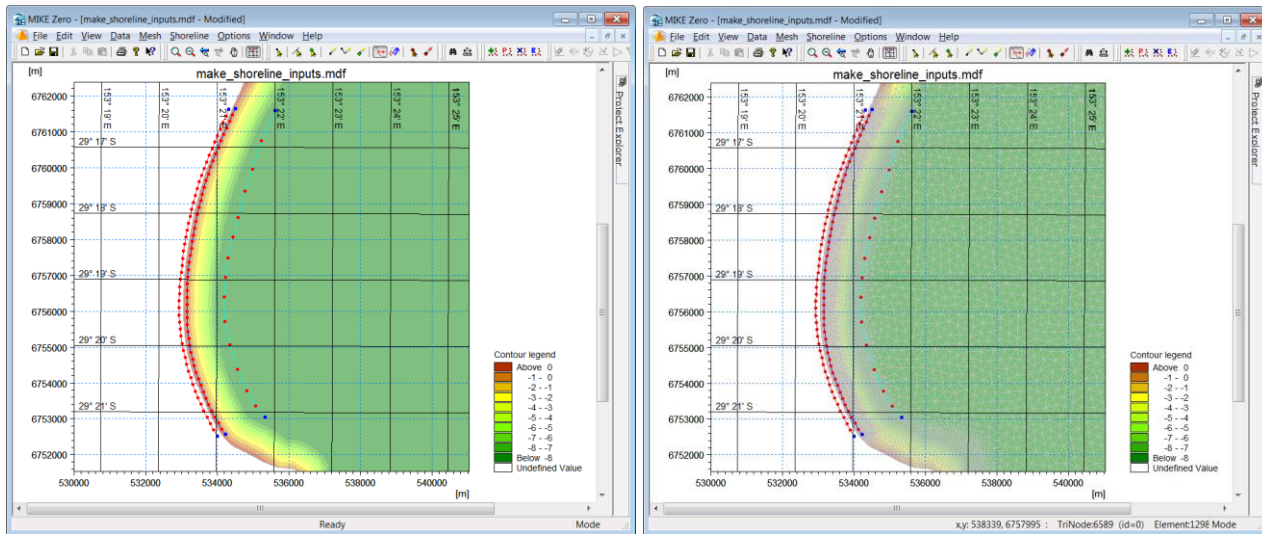


Figure 4.13 Offshore arc has been added beyond the 8 m contour but inside the fine resolution

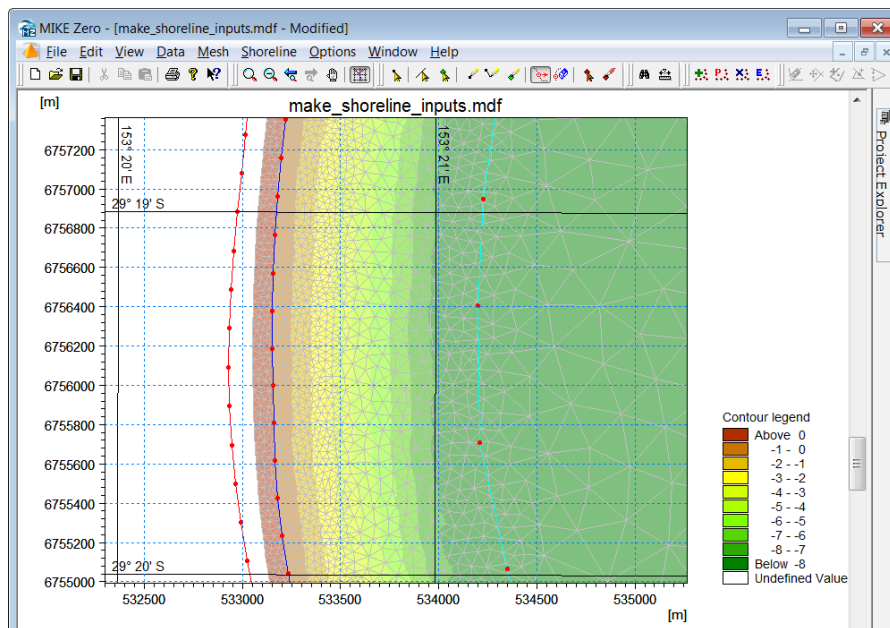


Figure 4.14 Zoom of Figure 4.13

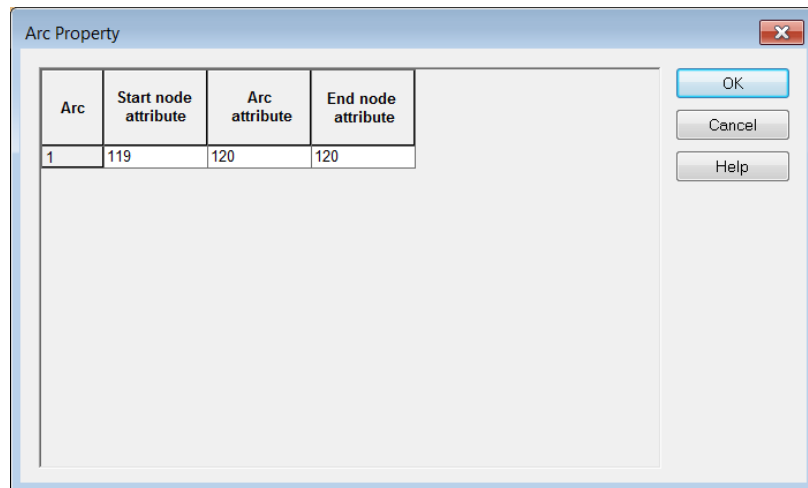


Figure 4.15 Setting attributes of off-shore arc

Now we can select *Manage edge map* from the *Shoreline* menu, set the attribute to the one we chose before and press *Create Edge Map*, see Figure 4.16.

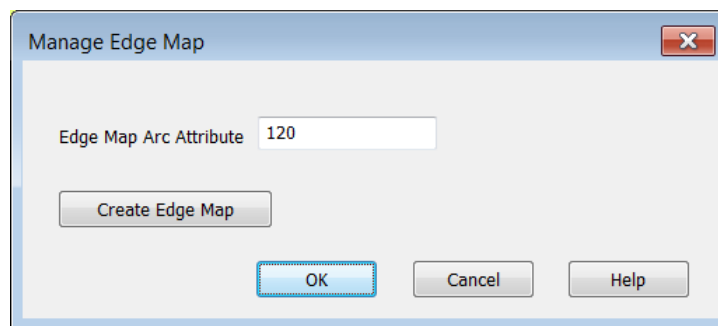


Figure 4.16 Manage Edge Map

Your edge map should now be visible as shown in Figure 4.17. If you changed your palette to *fixed* when drawing the shoreline arc you probably need to change it to *linear auto-scaled* (use Mesh -> Contour Palette -> New). We can now export the map by selecting *Export Edge Map* from the *Shoreline* menu.

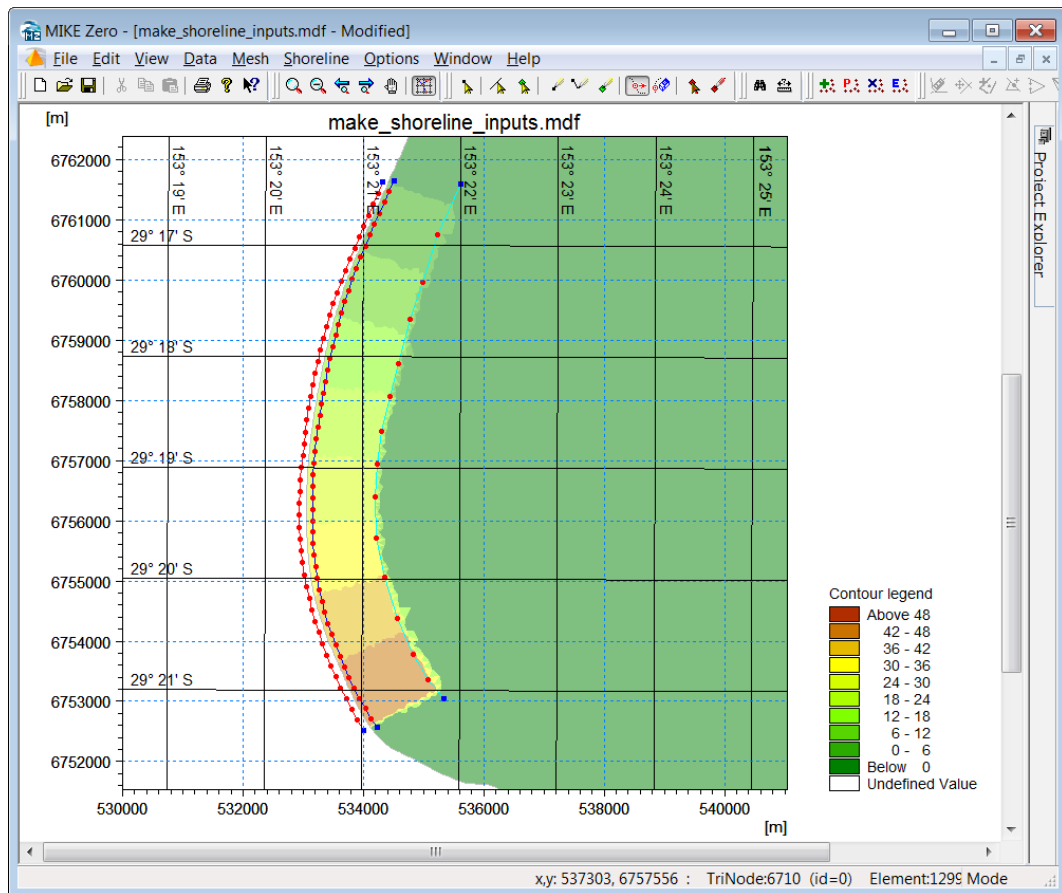


Figure 4.17 Edge Map.

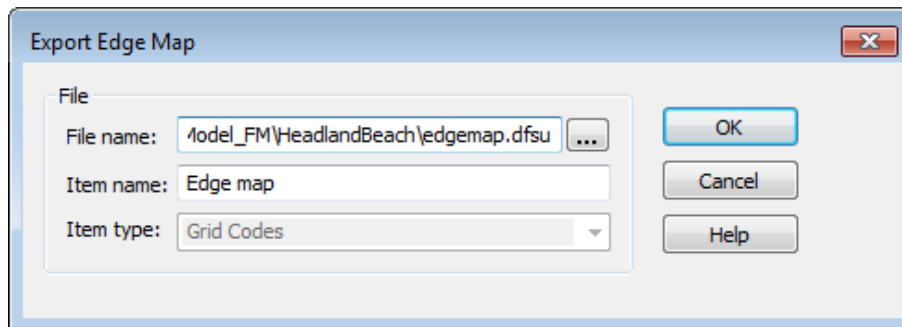


Figure 4.18 Export Edge Map

Once it has been exported, open it in the Data Viewer and check that it matches your expectations, first of all; that the strips do not cross and that the resolution of the mesh matches the resolution of the shoreline, i.e. each strip should be 3-4 mesh elements wide as shown in Figure 4.19.

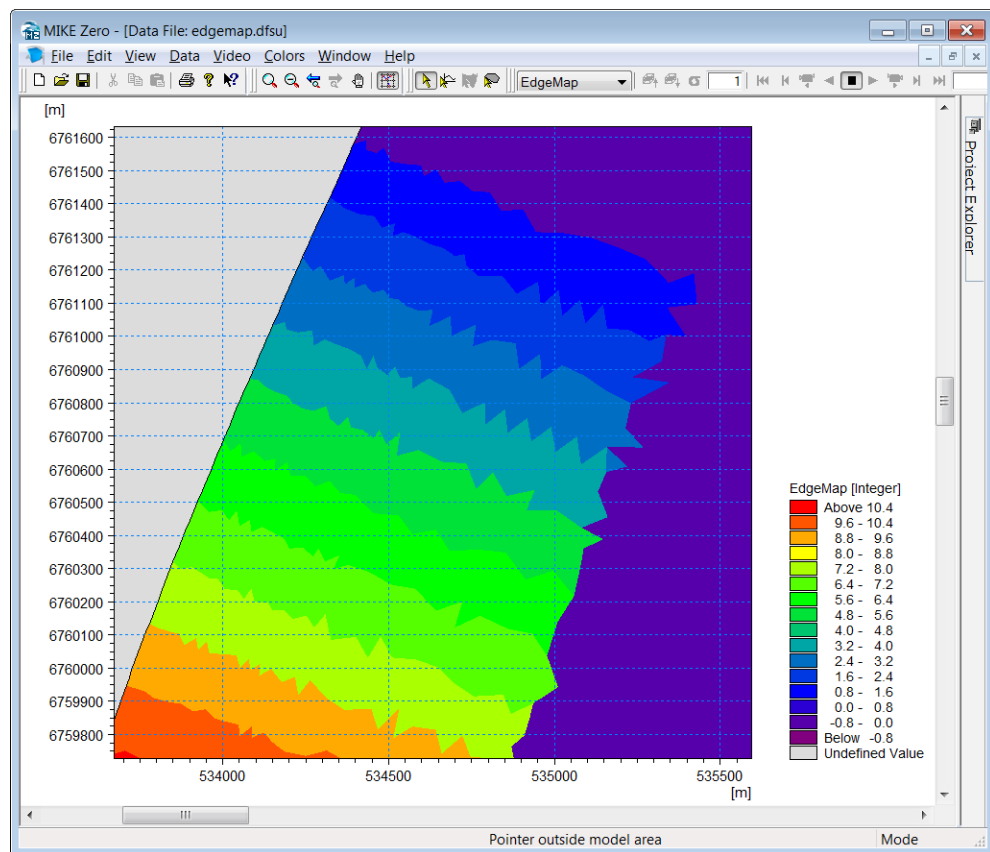


Figure 4.19 Edge map open in Data Viewer

## 4.5 Create Profiles

The last thing we need to create is the coastal profile; the coastal profile can either be loaded from xyz files or extracted from the bathymetry in the mesh. In the present case we will extract it from the mesh by reading in the mesh as a scatter data file as shown in Figure 4.20. Then please proceed to interpolate the scatter data onto the mesh.

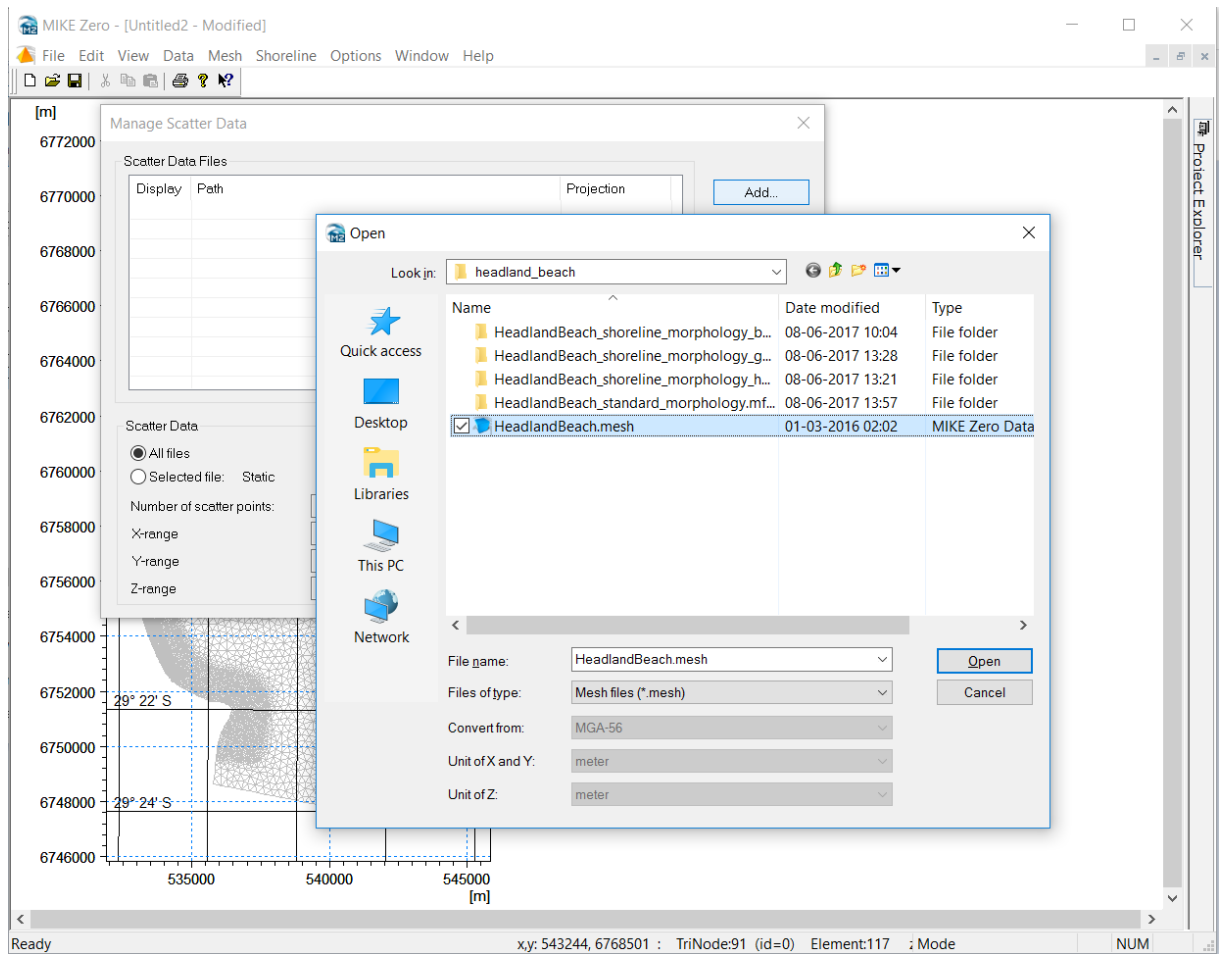
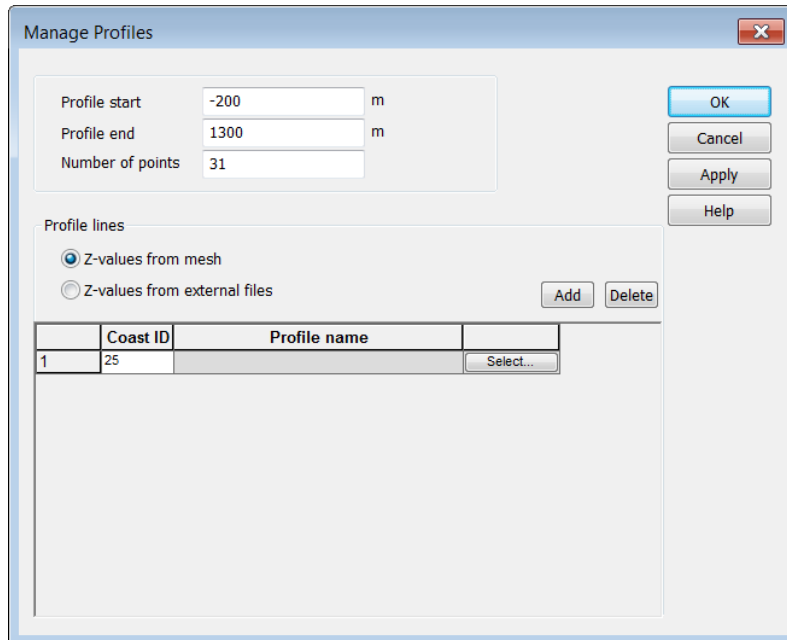


Figure 4.20 Load the xyz-data from an existing mesh file through the “Manage scatter data” menu.

Then select *Manage profiles* from the *Shoreline* menu and set the *Profile start*, *Profile end* and *Number of points* as shown in Figure 4.21.





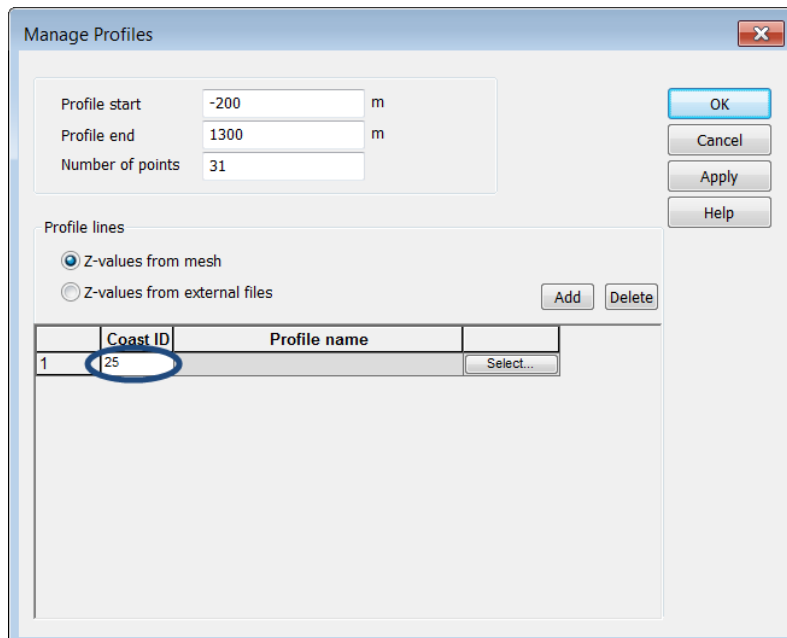
The 'Manage Profiles' dialog box contains the following elements:

- Profile start:** -200 m
- Profile end:** 1300 m
- Number of points:** 31
- Profile lines:**
  - ☒ Z-values from mesh
  - ☐ Z-values from external files
- Buttons:** OK, Cancel, Apply, Help, Add, Delete.
- Table:**

	Coast ID	Profile name	
1	25		Select...

Figure 4.21 Manage profiles. Note that the profile start is on land and the profile end is off-shore

In the current example the coastal profile is constant along the shoreline so we just need to extract a single profile. Do so by clicking Add, then select which profile to extract from the pull down menu shown in Figure 4.22. Pick a profile on the middle of the shoreline section, so select Coast ID 25 or similar then click Apply, OK and OK. You can now see the profile(s) you have selected and its extent as shown in Figure 4.23.



The 'Manage Profiles' dialog box is identical to Figure 4.21, but with the value '25' in the 'Coast ID' column of the table highlighted by a blue circle.

	Coast ID	Profile name	
1	25		Select...

Figure 4.22 Select profile for extraction from mesh

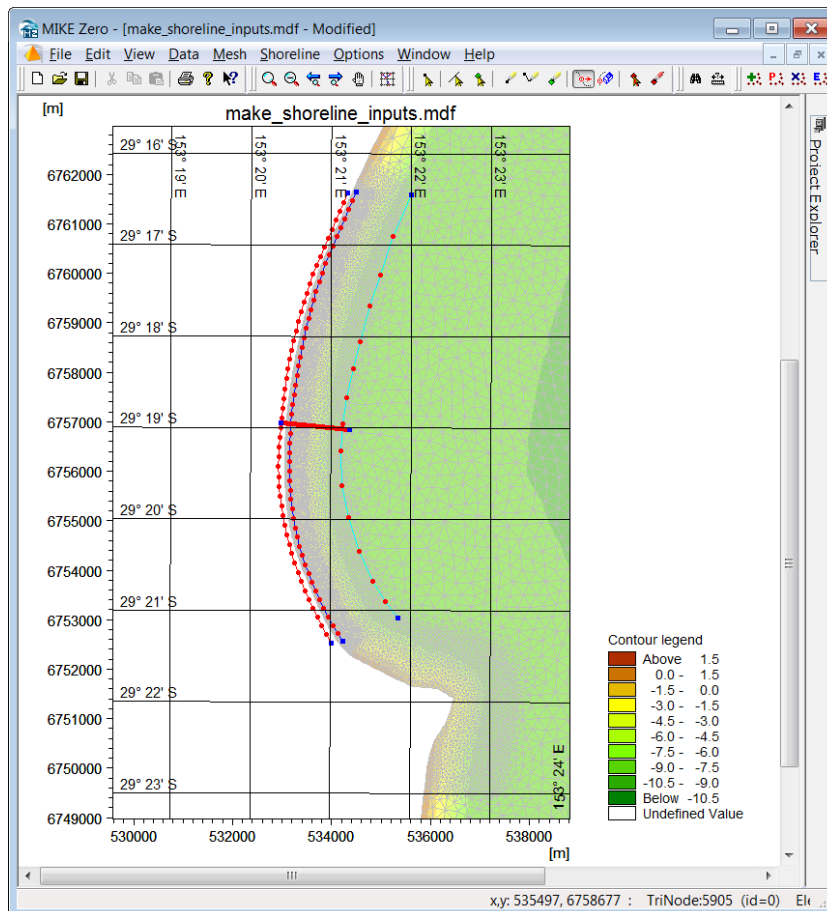


Figure 4.23 Location of selected profiles

If you are happy with the profile location and extent, the profile can now be exported to an xyz file using *Shoreline->Export Profiles*. Select *Single profile* and specify the file name to save the profile to (cf. Figure 4.24). Since we have only extracted one profile from the mesh the coast ID does not matter (all profiles along the baseline will be the same). But in case we had extracted more than one profile we could export the varying profiles as a dfs2 file instead.

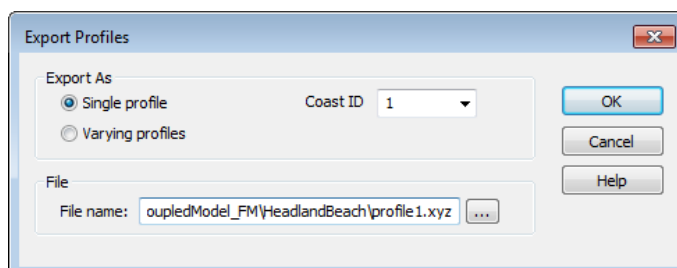


Figure 4.24 Export profiles

As we are now done creating our shoreline inputs, save the mdf file to a new name, e.g. *make\_shoreline\_model\_inputs.mdf*.

The last thing we need to do is to fix the profile onshore of the dune height and seaward of the closure depth so the gradient of the profile is steeper than the gradient in the mesh as shown in Figure 4.25. This can be done for the xyz file in any text editor; if the profiles

were varying, the dfs2 file would need to be fixed in the same way, this can be done using by opening and editing the file in MIKE ZERO.

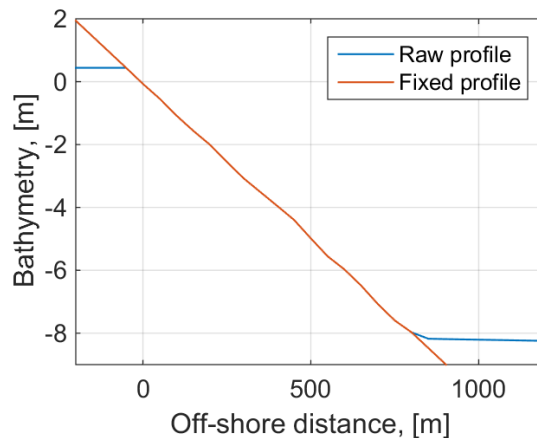


Figure 4.25 Comparison of raw (extracted from the mesh) and fixed profile

The procedure is to delete the set of values in the extracted profile which are below the closure depth and then add a single set of values to define the steep gradient as shown in Figure 4.26. The same thing should be done for the dune height.

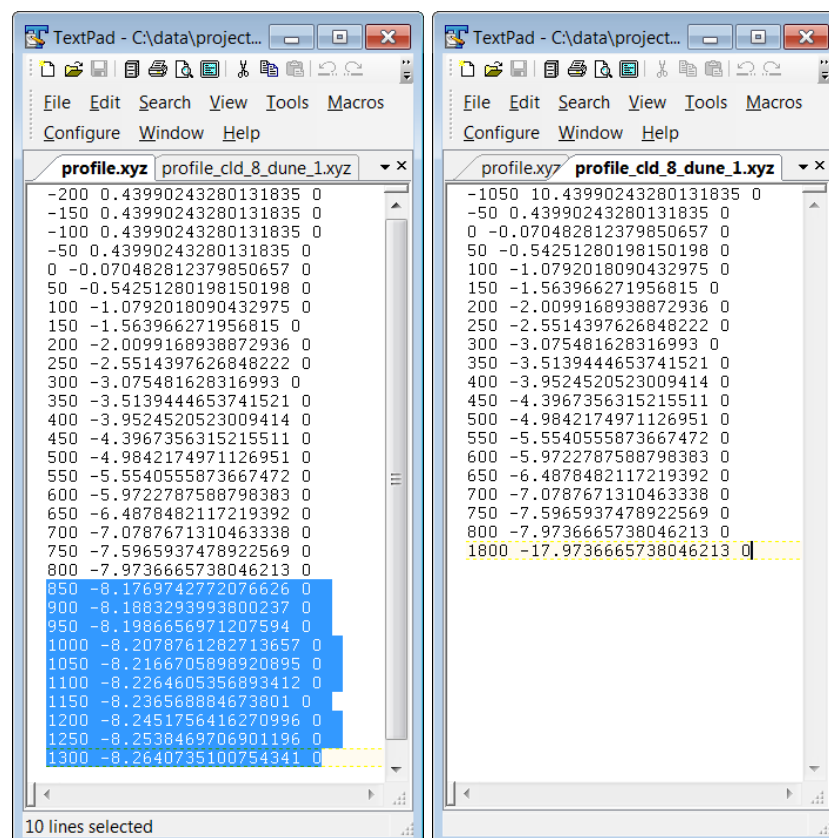


Figure 4.26 Delete the values below the closure depth (here = 8 m) marked with blue on the left panel. Then insert a single value pair defining a steep gradient of 1/100 shown in the right panel

Now we are ready to setup and run the Shoreline Morphology model in the next section.



## 5 Baseline Case

In this section we will setup and run the Shoreline Morphology model for the baseline case, i.e. without any mitigation measures.

### 5.1 Setup the Shoreline Morphology Model

Our starting point is the coupled HD, SW and ST setup named [HeadlandBeach\\_standard\\_morphology.mfm](#), so open this file and save it under a different name, e.g. HeadlandBeach\_shoreline\_morphology.mfm. Then activate the *Shoreline morphology* in the Module Selection section as shown in Figure 5.1. As seen, the model is telling us on the bottom panel that the *baseline*, *coastline*, *edge map* and *profile* inputs are missing from the Shoreline Morphology model.

In each section simply point to the files created in the previous section or to the files supplied in the example folder as shown in Figure 5.2, Figure 5.3, Figure 5.4 and Figure 5.5. In the profile section also set the closure depth (= 8 m) and the dune height (= 1 m).

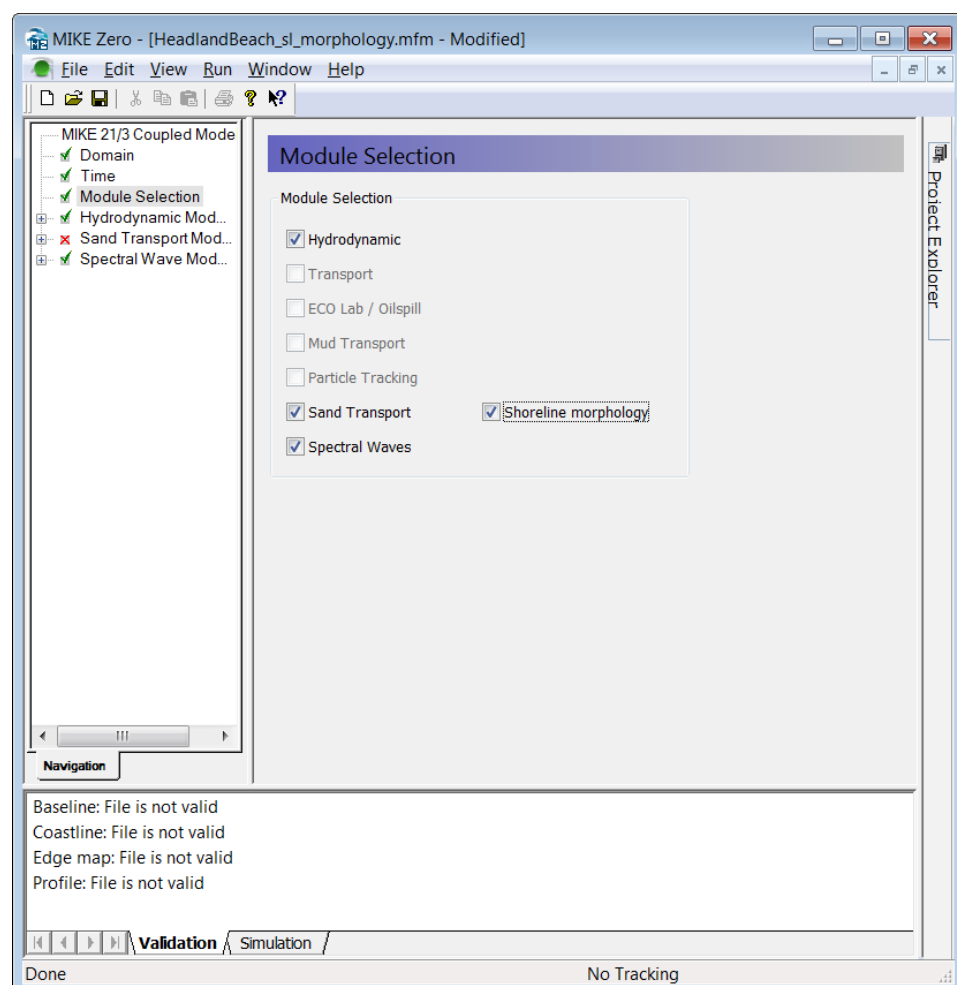


Figure 5.1 Activate Shoreline morphology

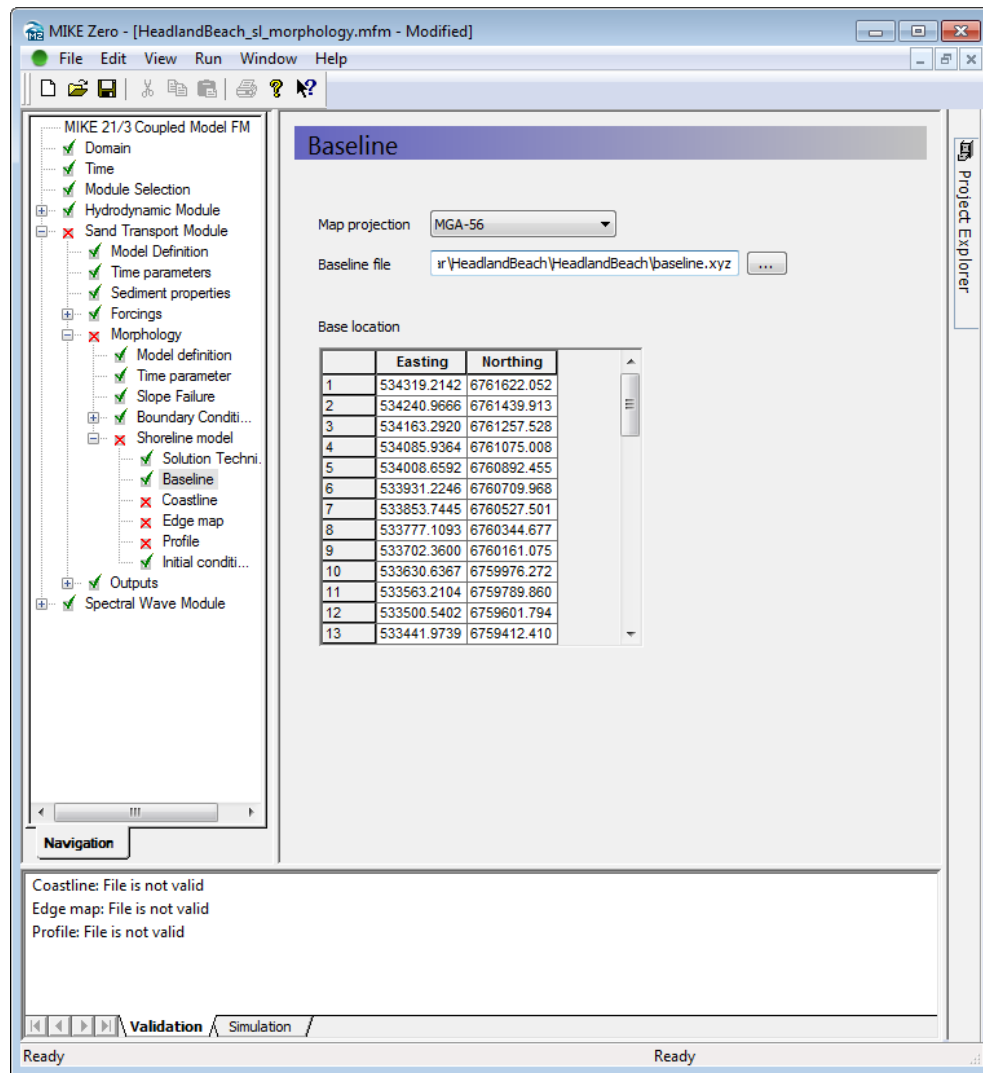


Figure 5.2 Select Baseline file

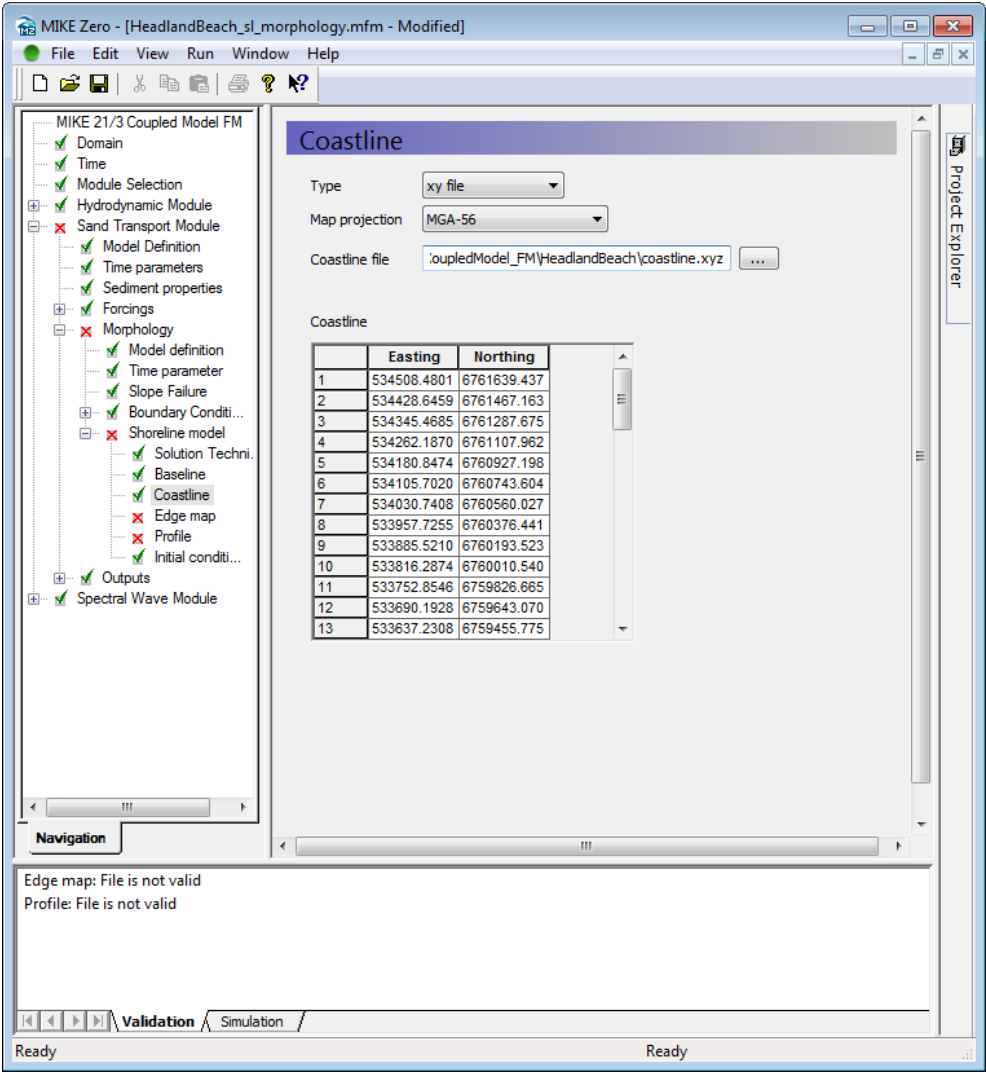


Figure 5.3: Select Coastline file

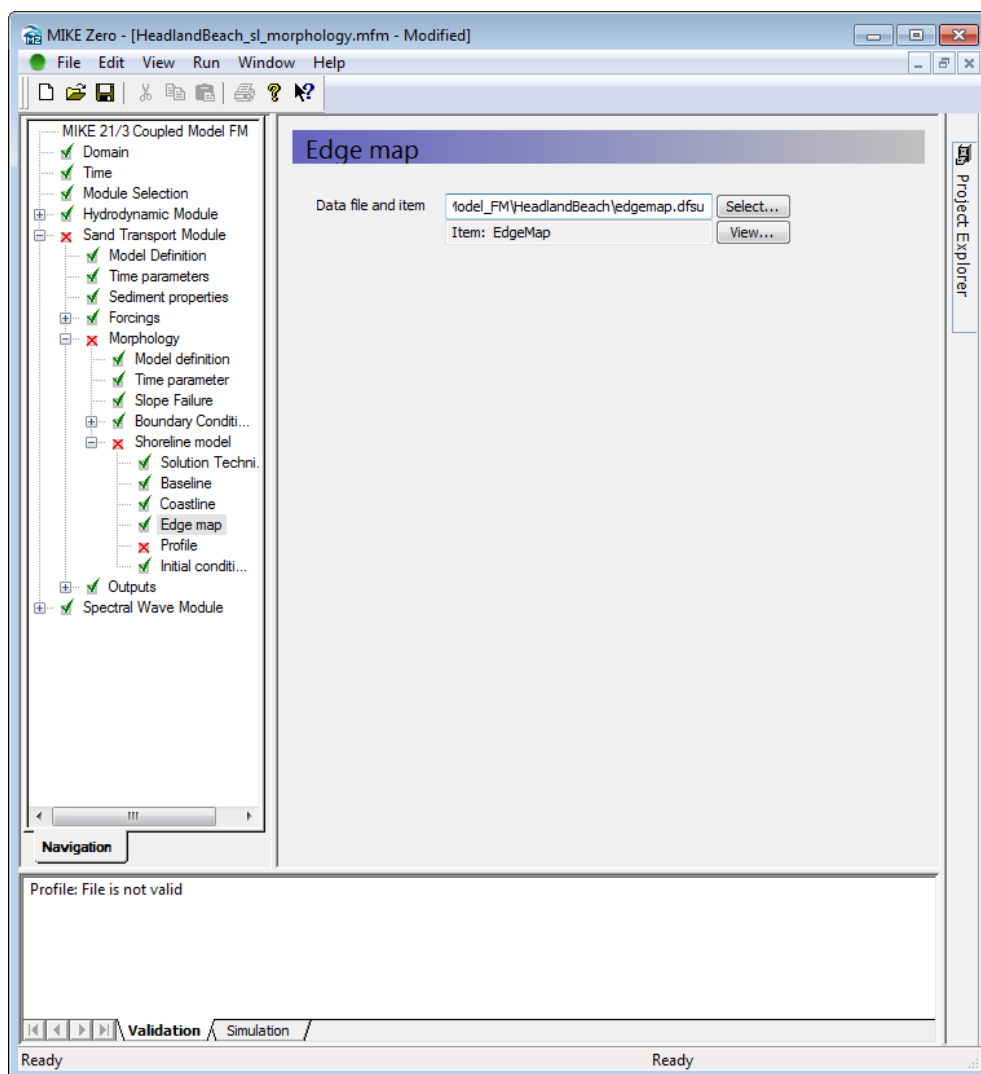


Figure 5.4 Select Edge map file



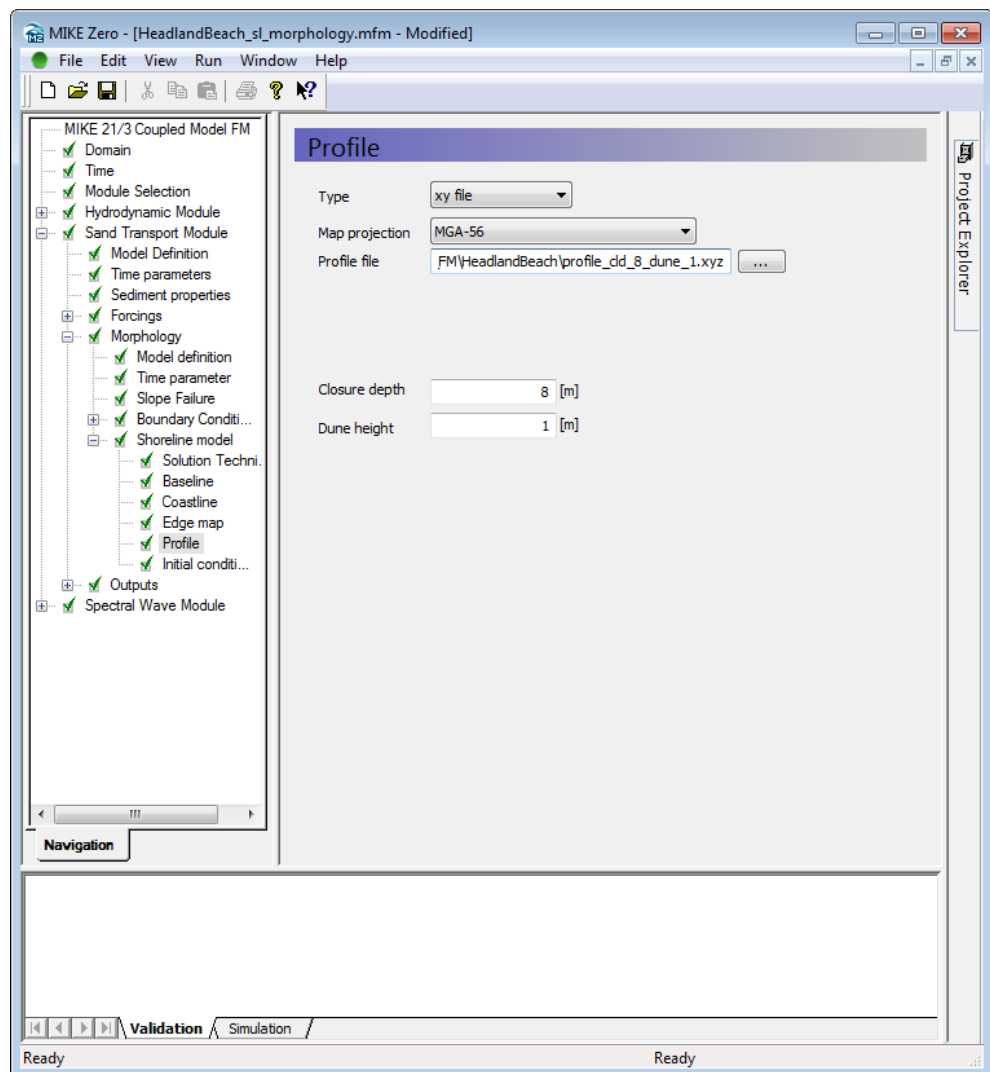


Figure 5.5 Select Profile file and set Closure depth and Dune height

Check the solution technique section (in the shoreline model section), normally the default values are OK, but if your model is not converging within the specified 100 iterations, increase the tolerance in this section. It is important that the model converges for most time steps, if the maximum number of iterations is reached, the iterated solution is not used, rather the solution found directly from the modified one-line equation is used; this may contain small mass errors which add up over the long term.

In MIKE 2017 a new feature was introduced to remove exchange of sediment over the offshore boundary/closure depth. The feature ensures by default that any loss/supply of sand over the offshore boundary/depth of closure does not impact the volume calculations that affect the shoreline evolution.

Note that the simulated offshore/onshore volumes along the offshore boundary/depth of closure is written to the coastline.dfs1 output file regardless of whether the effect of offshore transport is included or excluded in the volume balance.

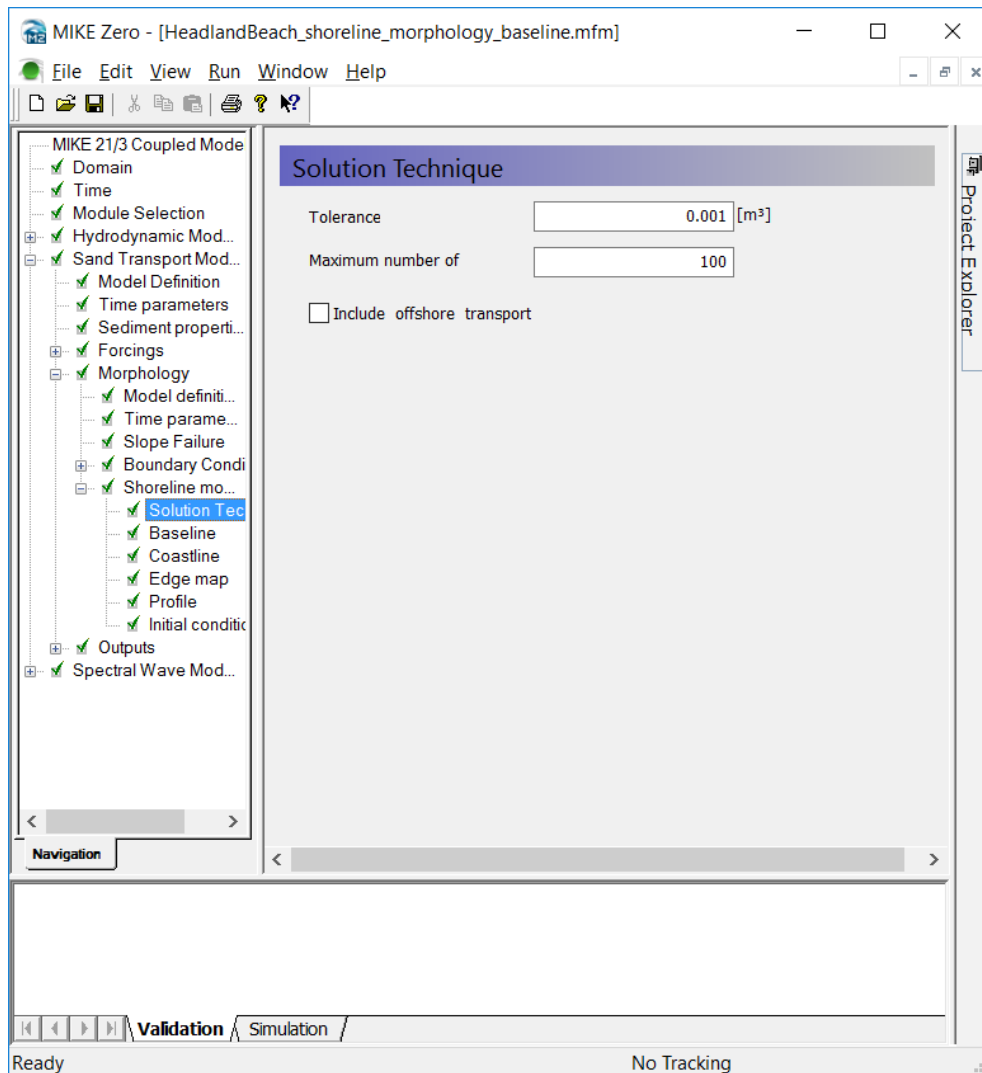


Figure 5.6 Solution Technique

Once we have specified all the inputs we can check that they look OK by clicking on the Shoreline Morphology section as shown in Figure 5.7.

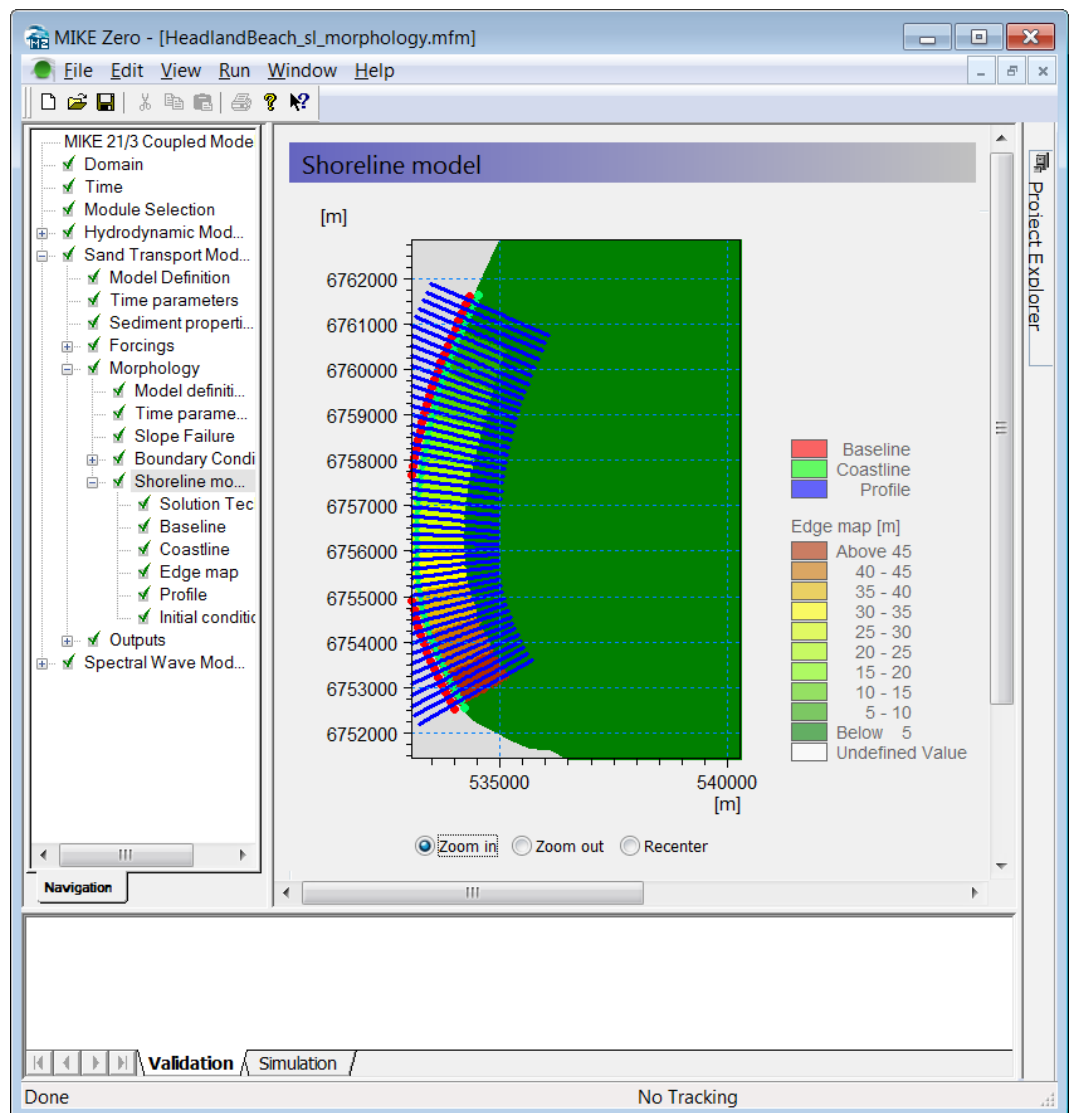


Figure 5.7 Check inputs in the Shoreline morphology section

Finally, we need to specify a new output, which contains the results from the Shoreline Morphology model. So in the outputs section of the *Sand Transport Module* add a new output and select Coastline for field type as shown in Figure 5.8. Select the variables that you want to place on the Output items tab as shown in Figure 5.9.

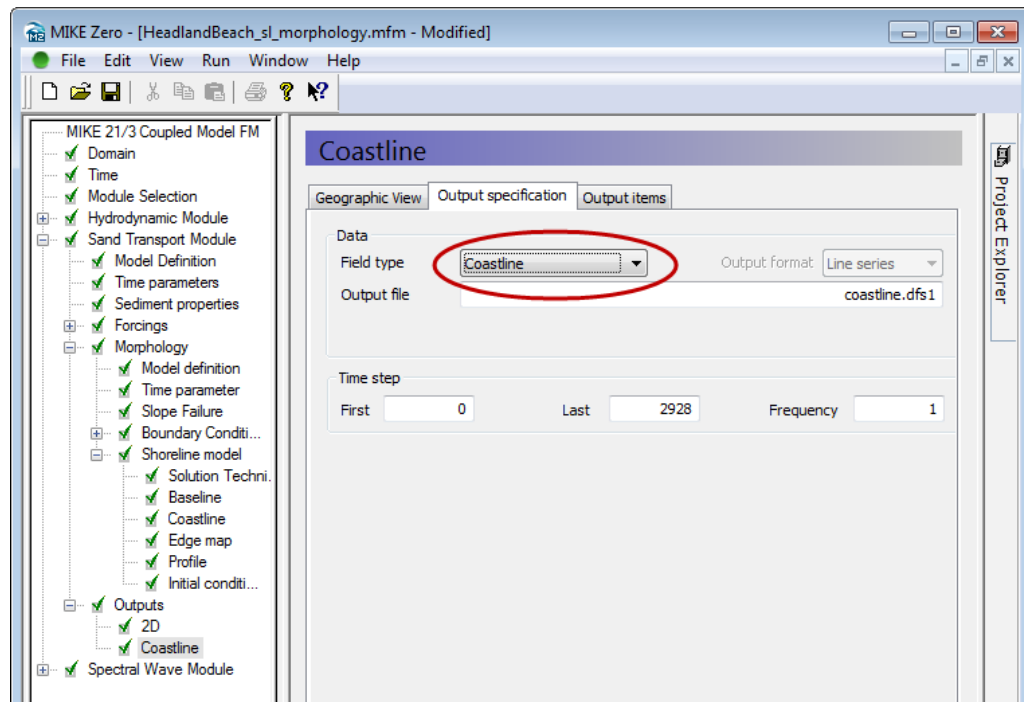


Figure 5.8 Specify the Coastline output and give the new output a name

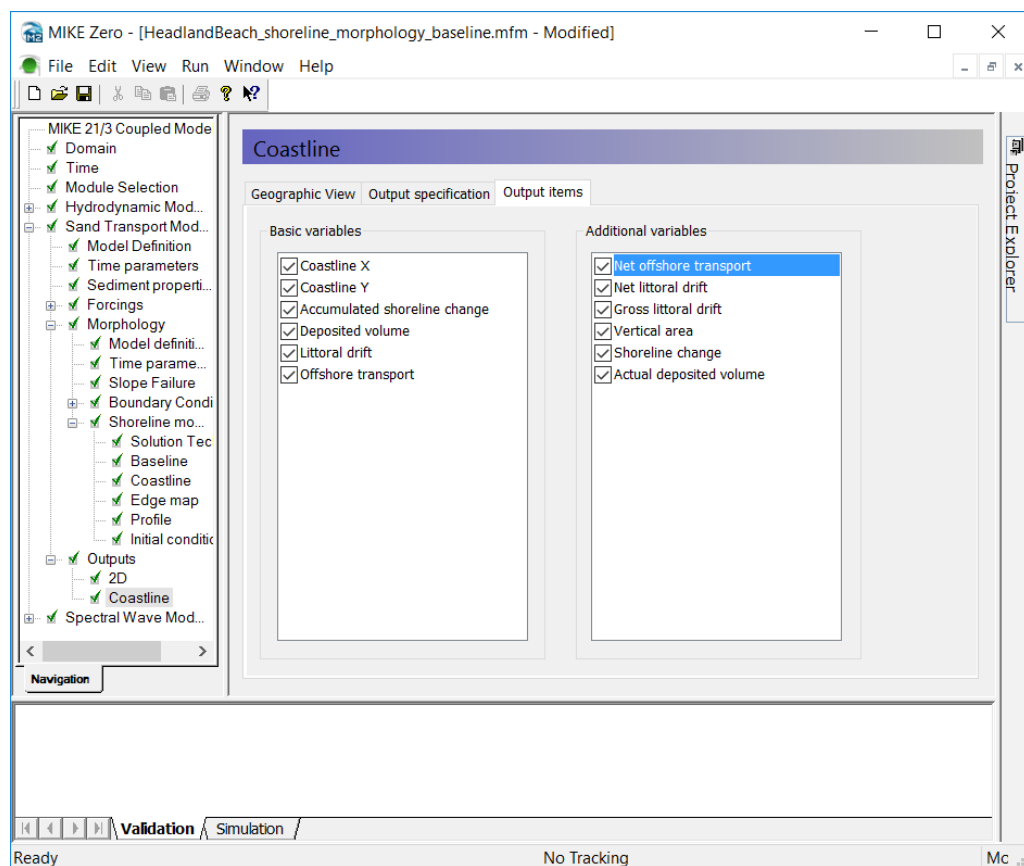
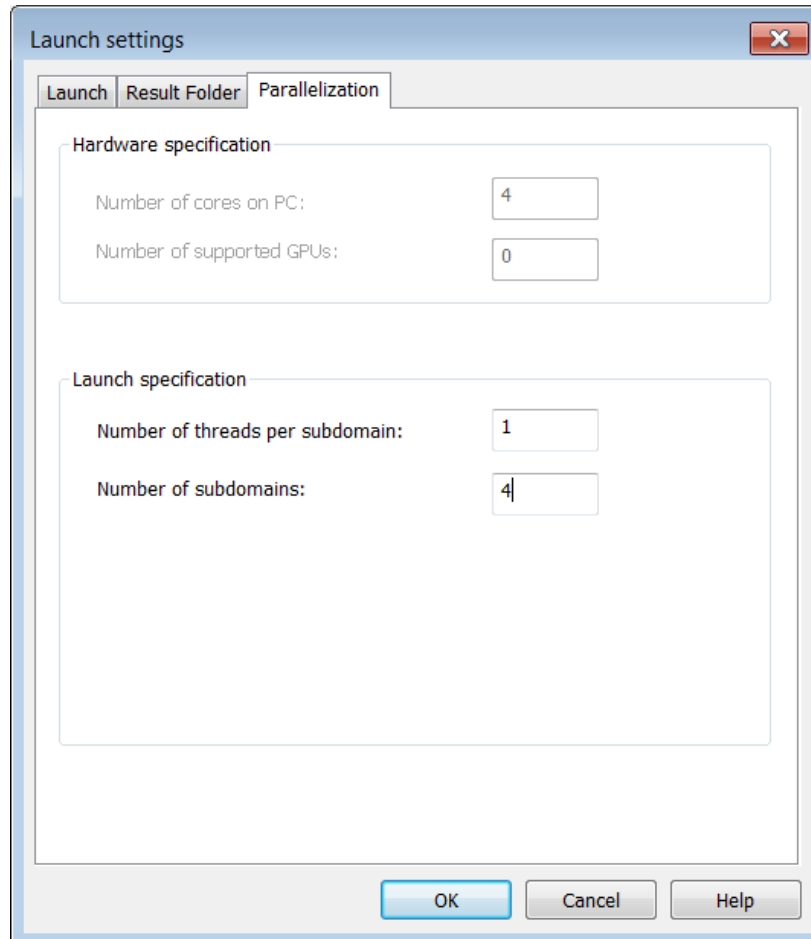


Figure 5.9 Select items for the Coastline output

## 5.2 Run the Shoreline Model

Now we are ready to run the model, select 'Run -> Start simulation' and make sure you set the number of *threads per subdomain* and *Number of sub-domains* to sensible values, i.e. one times the other should not be more than the number of available cores.



The image shows a 'Launch settings' dialog box with three tabs: 'Launch', 'Result Folder', and 'Parallelization'. The 'Parallelization' tab is selected. It contains two sections: 'Hardware specification' and 'Launch specification'. In the 'Hardware specification' section, 'Number of cores on PC:' is set to 4 and 'Number of supported GPUs:' is set to 0. In the 'Launch specification' section, 'Number of threads per subdomain:' is set to 1 and 'Number of subdomains:' is set to 4. At the bottom are 'OK', 'Cancel', and 'Help' buttons.

Section	Parameter	Value
Hardware specification	Number of cores on PC:	4
	Number of supported GPUs:	0
Launch specification	Number of threads per subdomain:	1
	Number of subdomains:	4

Figure 5.10 Launch settings

Click OK and the model should start running. After a few time steps all three modules should be converging very fast at each time step. This is because of the constant boundary conditions in both the HD and SW modules. Note that the estimated time for the model to finish will be large in the beginning when the HD and SW modules are finding the quasi steady solution, but should reduce significantly. On a 4 core laptop the model is running in around 15 minutes.

You can check that the modules are converging by looking the output of convergence files that you can specify for the SW and HD module. Convergence information for the SM model is written in the bottom panel as shown in Figure 5.11. Note that the MD: lines are from the Shoreline Morphology model, it is not written whether the model converged or not, but when the number of iterations is smaller than the maximum number of iterations (default = 100) specified in the solution technique section, then the model has converged.

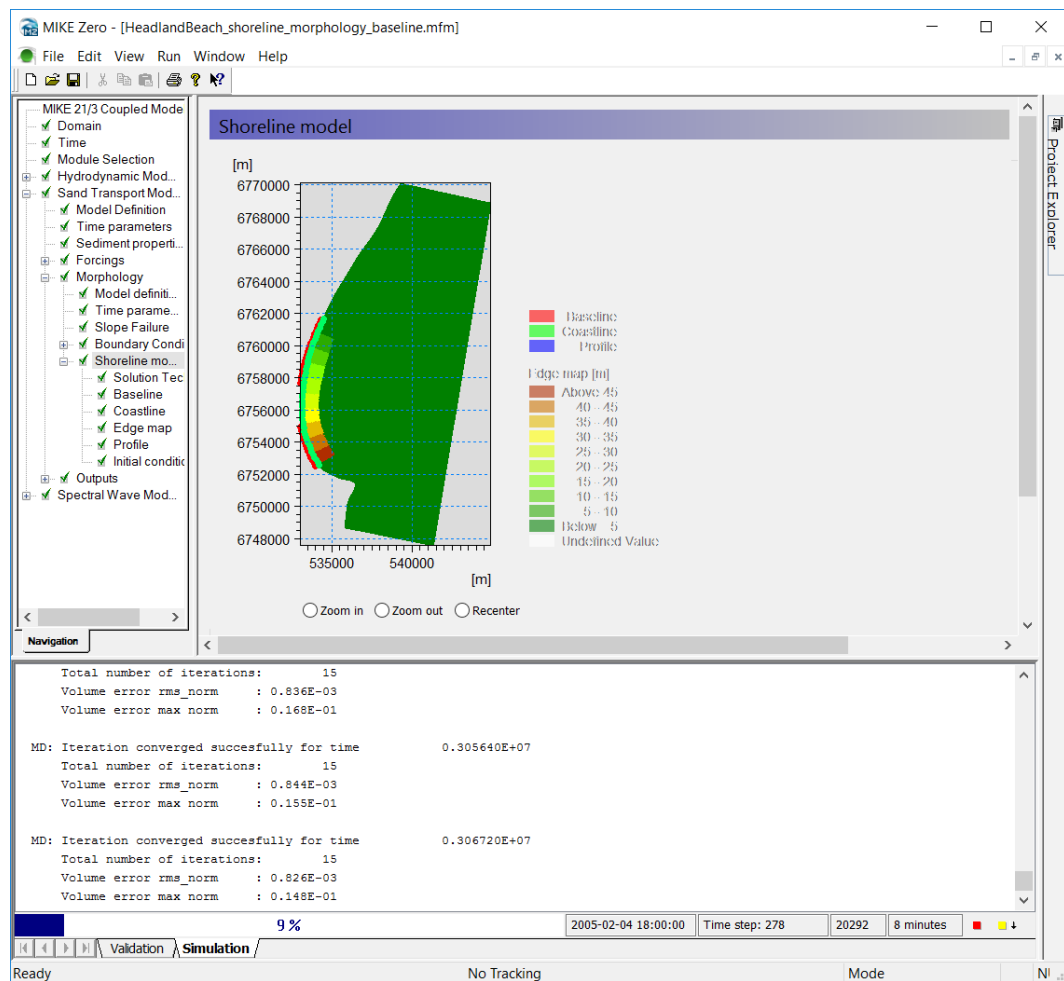


Figure 5.11 Check that the SM module is converging in the simulation window

## 5.3 Initial Results

The first result we will look at is the littoral drift along the shoreline. Even if the model is still running we can look at this result and start thinking about it. Click on the View button next to the coastline result in the Outputs section of the Sand Transport Module as shown in Figure 5.12.

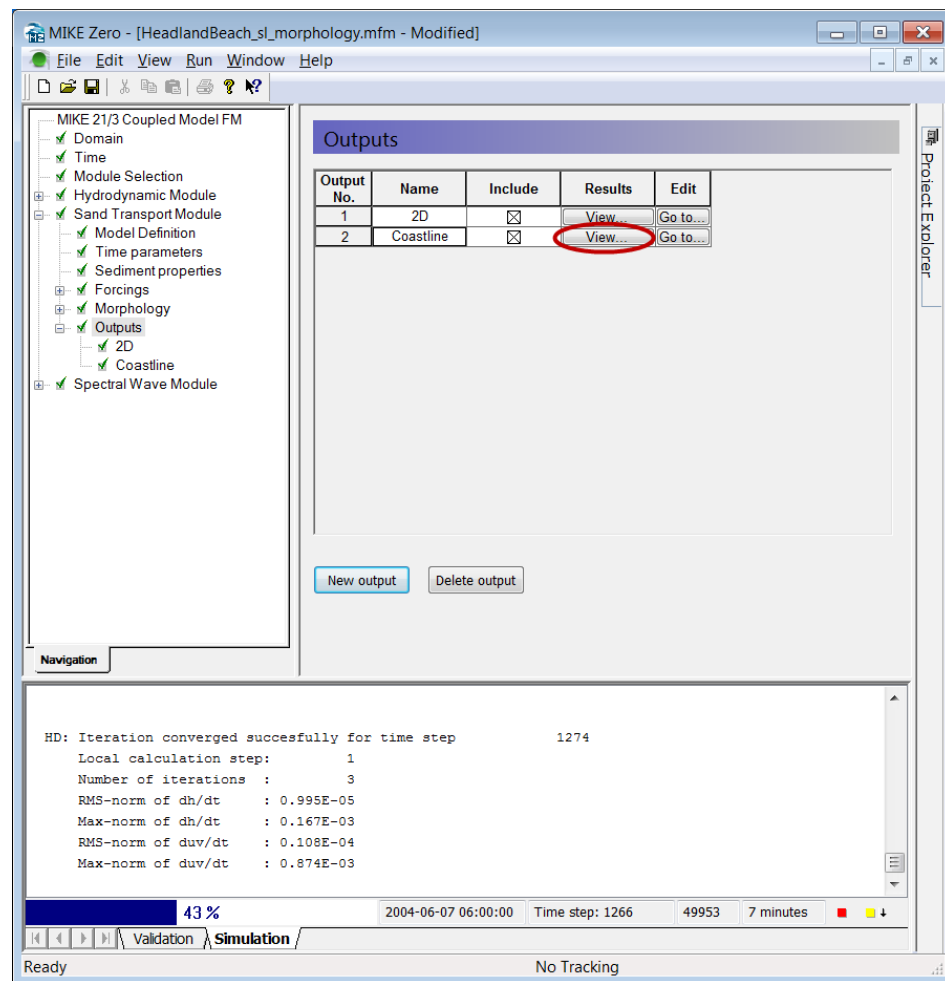


Figure 5.12 Click on the View button to view results from the Shoreline Morphology model

The dfs1 file should open, and we can select the littoral drift item as shown Figure 5.13.

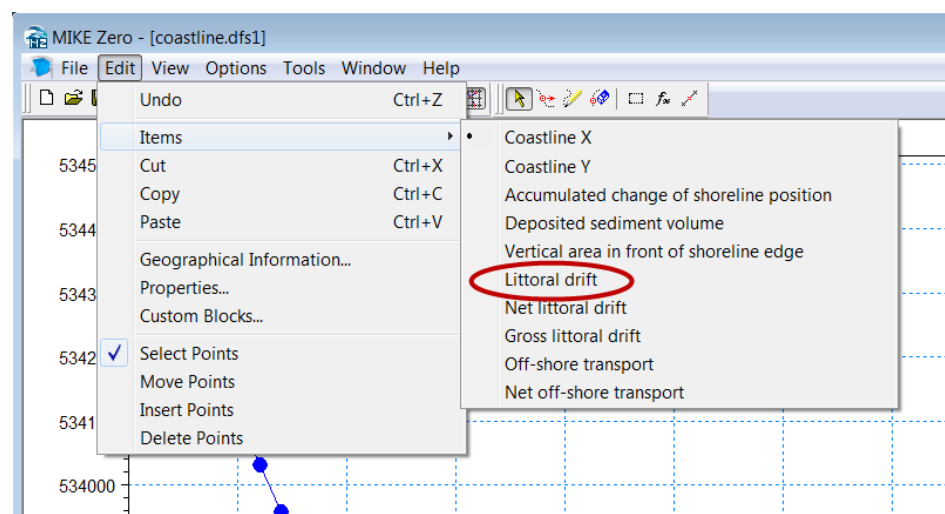


Figure 5.13 Select the Littoral drift item

Move down some time steps until the littoral drift has stabilized (in time) as shown in Figure 5.14. The first point is the leftmost when standing on the beach and looking seaward; thus the first point is northernmost and the last point is the southernmost. The littoral drift is positive going to the right. So for these wave conditions we have increasing northward transport when moving from the southern end of the baseline towards the centre of the baseline and then slightly decreasing littoral drift along the rest of the baseline towards the north. Thus we expect to see erosion on the southern end of the area of interest and more stable development on central and north sections. As the shoreline position reacts to the gradients in the littoral drift, many of the spikes in the drift go away as shown in Figure 5.14.

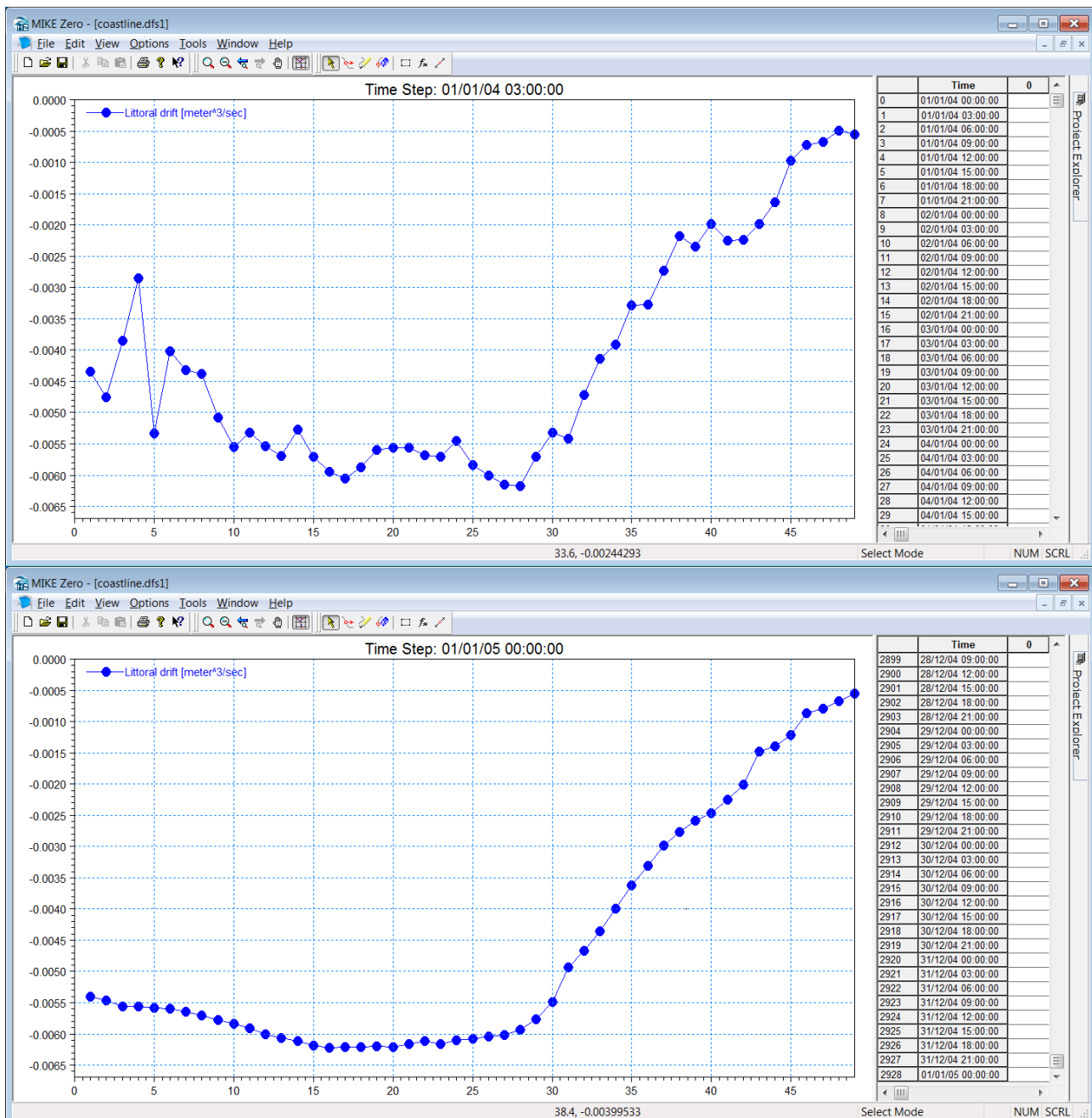


Figure 5.14 The littoral drift along the baseline. Top: in the beginning of the simulation. Bottom: At the end of the simulation



Switching to the accumulated change of shoreline position we can see the erosion and accretion pattern along the baseline as shown in Figure 5.15. It is noted that the signal is noisy; the noise is due to the limited mesh resolution and the highly non-linear nature of sediment transport in the surf zone. We can get rid of some of the noise by refining the mesh or running the model again and using our results from the first run as input to the second run, (i.e. the run we just completed is a warm-up run).

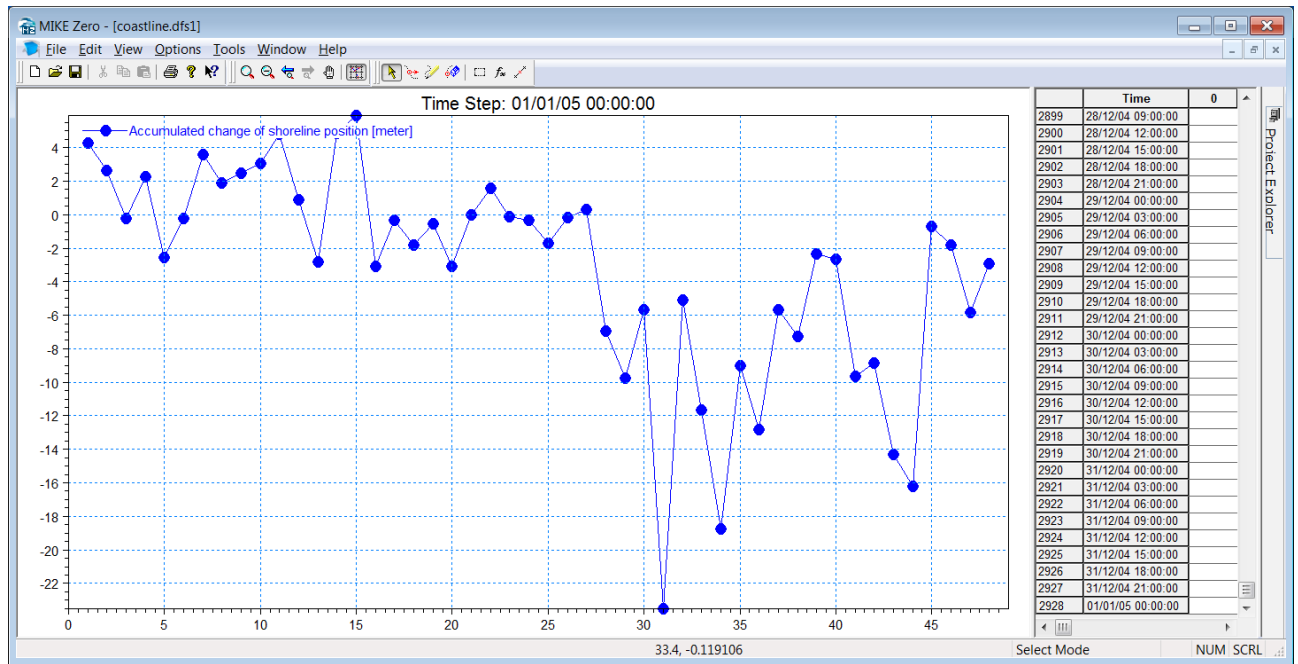


Figure 5.15 Accumulated change in shoreline position at the end of the simulation

## 5.4 Setup using Warm-up Result

Save the setup file to a new name, e.g.:

HeadlandBeach\_shoreline\_morphology\_baseline.mfm

and change the start year of the simulation to 2005. Then change the coastline file type to dfs1 file and point to the result file from the simulation which just finished as shown in Figure 5.16. Then run the model again. This new model will be our baseline Shoreline Morphology model.

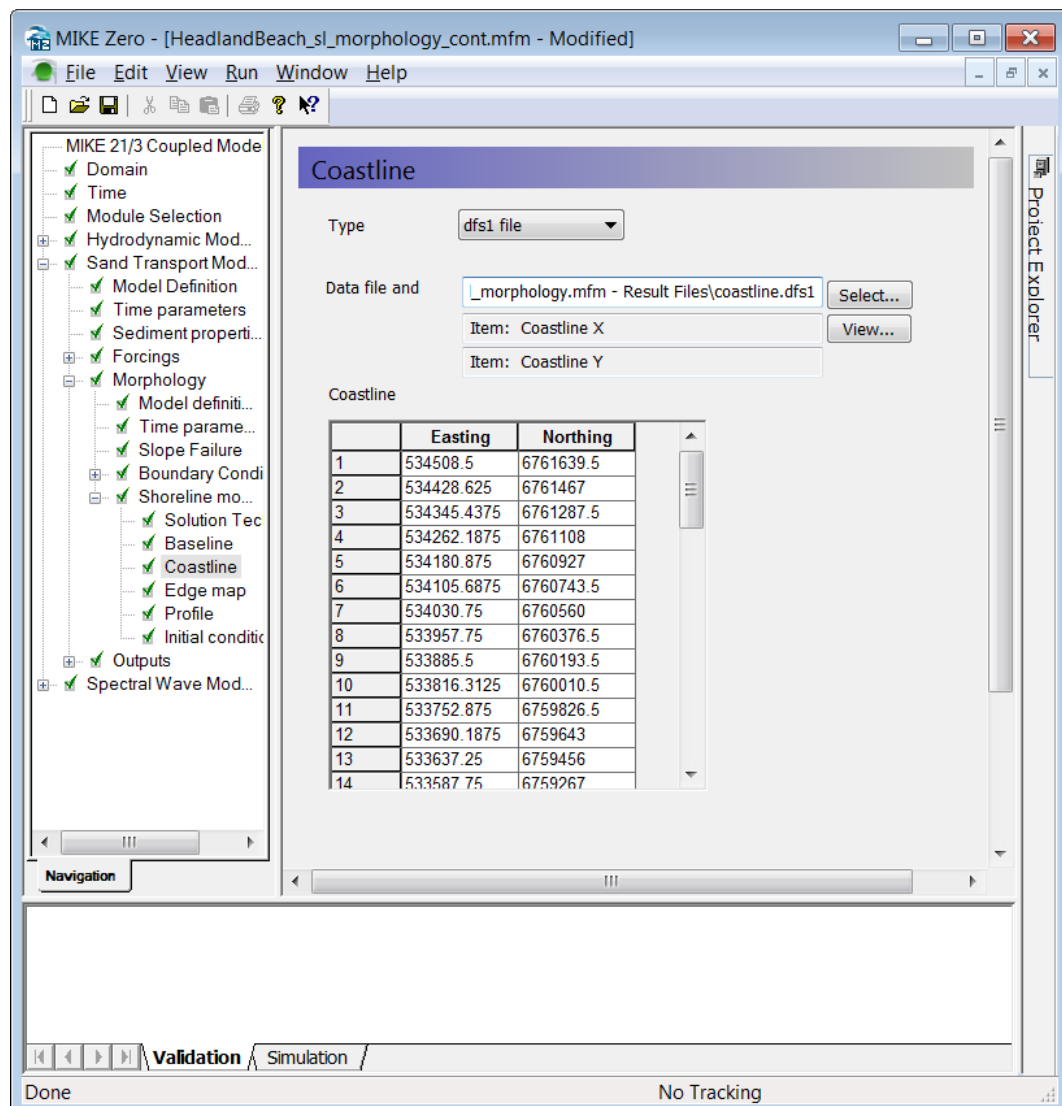


Figure 5.16 Change the type of the coastline input to dfs1 and point to the result file from the previous simulation

## 5.5 Results

While the new model is running we can have a look at some of the other results.

Next switch to the item named *Net offshore transport*. This item shows the accumulated transport across the closure depth for each shoreface strip, i.e. into/out of the Shoreline Morphology model domain. To get a perspective on the size of this transport it is a good idea to look at the item *Vertical area in front of shoreline edge*. The accumulated change in shoreline position due to the net offshore transport is the *Net offshore transport* divided by the *Vertical area in front of shoreline edge*. Look in the *General Description* of the shoreline model in the help section (press F1 to bring up the help) or in the User Guide, which can be accessed via the MIKE Zero Documentation Index in the start menu:

[MIKE 21 Flow Model FM, Sand Transport Module, User Guide](#)

In some cases the off-shore transport can be a significant contribution and it must be considered if this contribution is wanted or not; in many cases we do not want to include the impact of the off-shore transport on the change in shoreline position in which case it can be removed in a post-processing step. In the present case it is found that the net off shore transports accounts for less than 0.5 m of shoreline movement at the location with the largest net off-shore transport.

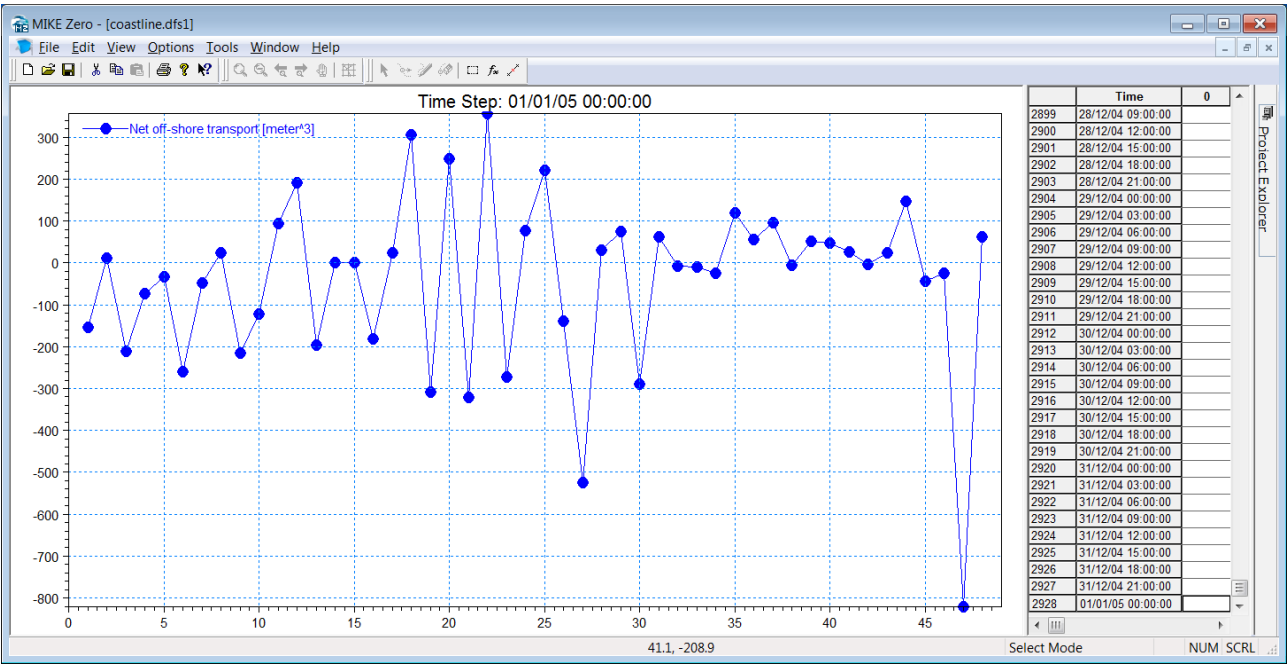


Figure 5.17 Net off-shore transport

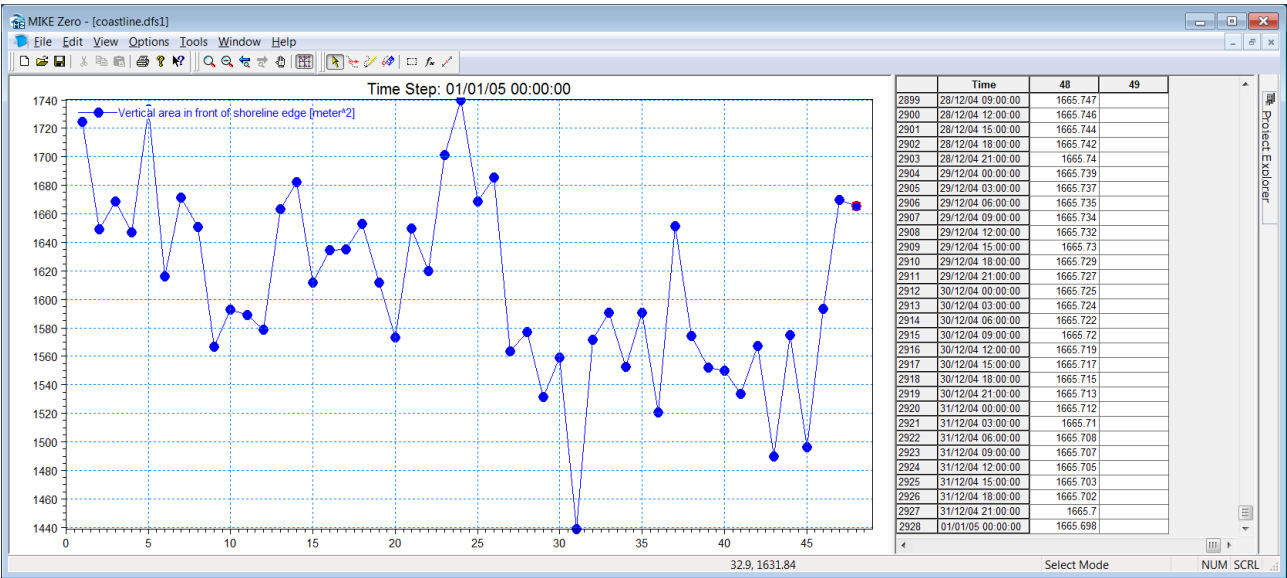


Figure 5.18 Vertical area in front of each shoreline edge

Once your baseline model simulation is done you can have a look at the accumulated change in shoreline position to see if the warm up run made a difference. Figure 5.19 shows the accumulated change in shoreline position after 1 year for the warm-up run and the baseline run. It is seen that the spikes are smaller for the baseline run, so the warm-up does have an effect although there are still some large spikes in the baseline run; these can be removed by running the warmup run for a longer period.

As it is almost impossible to set the initial shoreline position to be in equilibrium with the forcing from the waves, it is normally recommended to perform a warm-up run to remove the initial reorientation of the shoreline from the actual results.

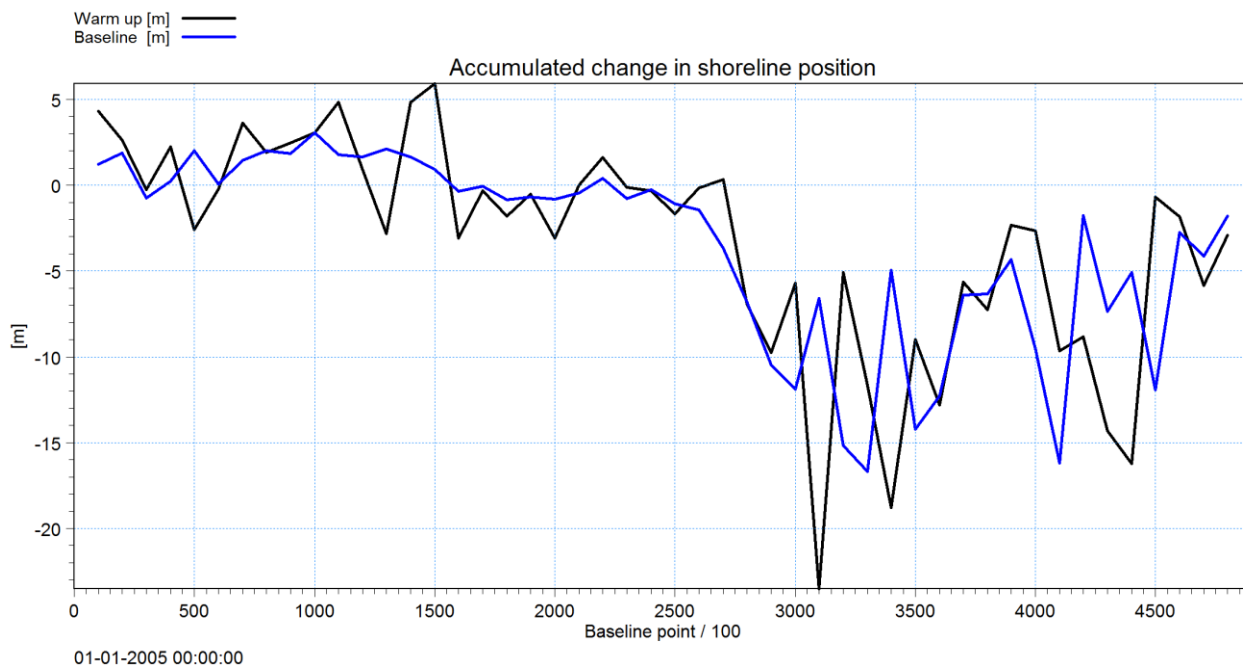


Figure 5.19: Comparison of the accumulated change in shoreline position after 1 year for the warm-up run and the baseline run. Note that the x axis shows baseline point number \* 100, so 3000 = point 30

The initial bed level change is shown in Figure 5.20 is the difference between the bed level in the mesh file and the bed level determined by the specified coastal profile and initial shoreline position in the Shoreline Morphology model. While this is nice to know, it disturbs the change in bed level for all other time steps, so it is a good idea to remove this initial bed level change from the bed level change of the remaining time steps. This can be done using the Data Manager as explained in the following.

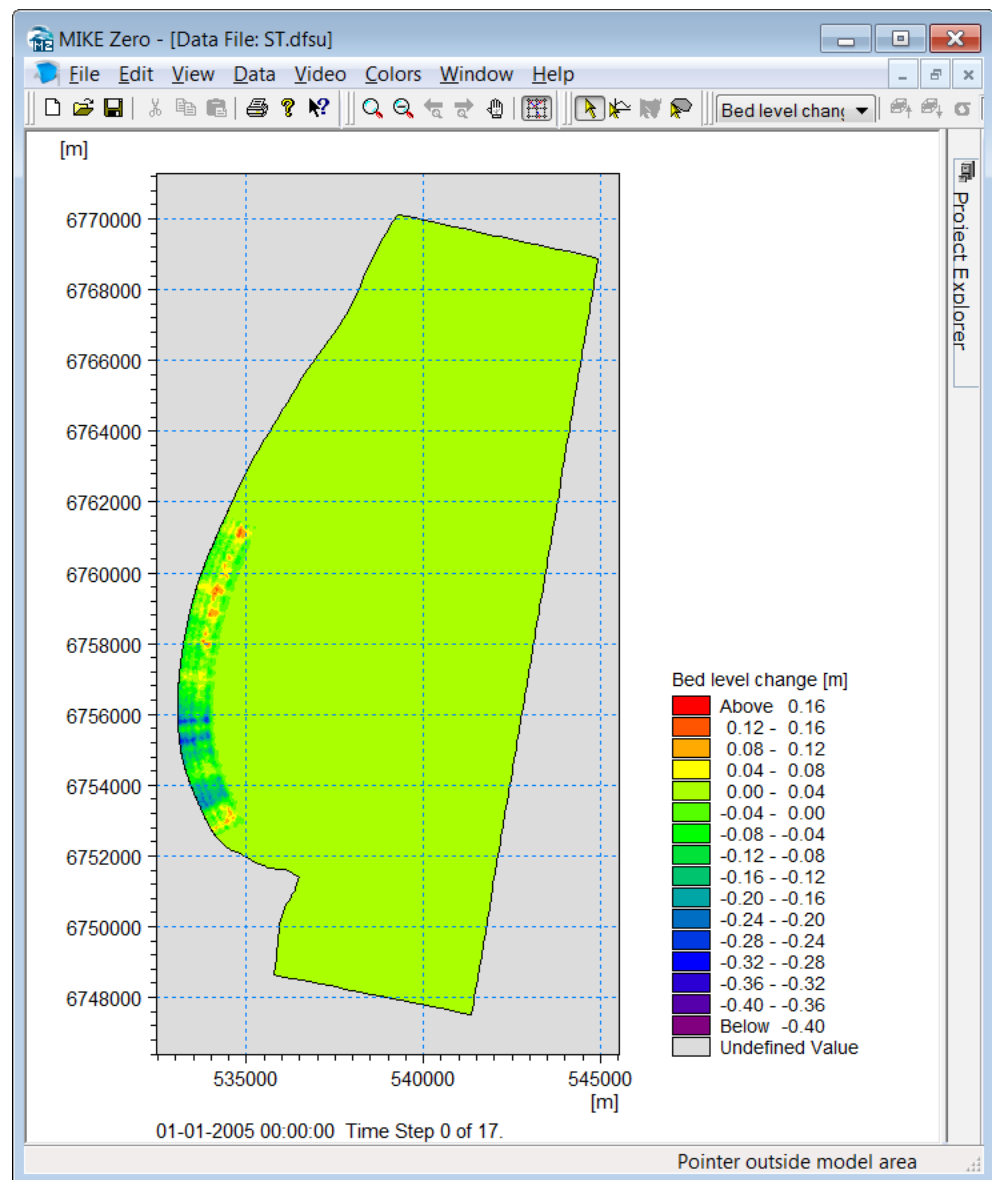


Figure 5.20 Initial bed level change

First, extract the bed level change at the first time step using *Data Extraction FM* as shown in Figure 5.21, it is important to only extract the first (i.e. 0 ) time step.

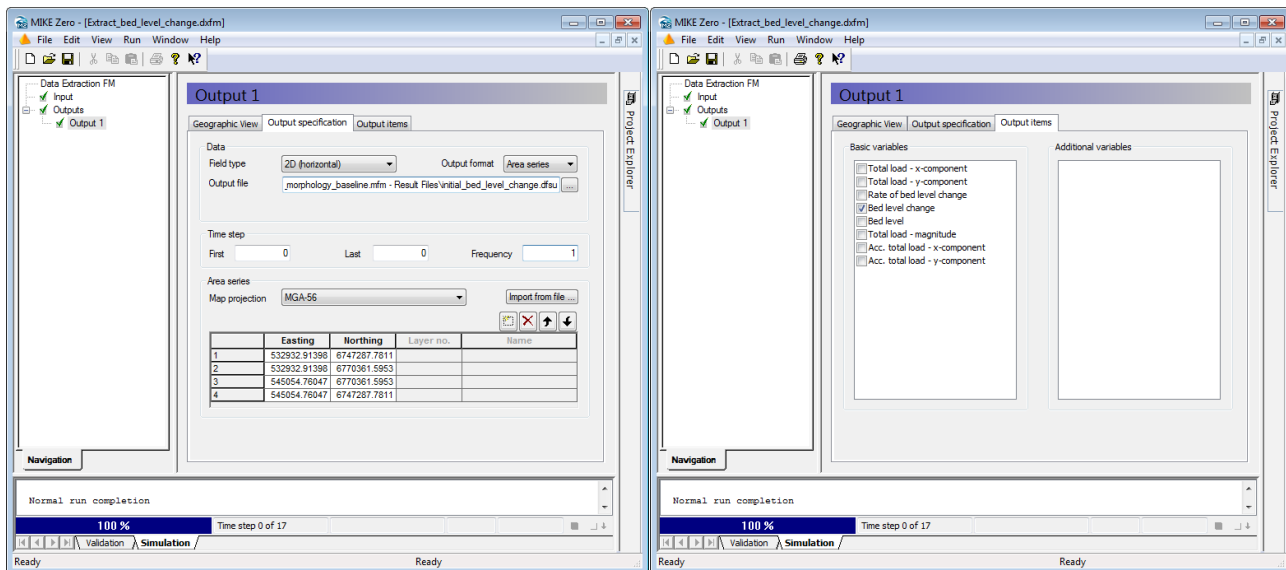


Figure 5.21 Extract the bed level change for the initial time step

Open the .dfsu file in DataUtility and increase the time step to cover the length of the simulation period. Then open the ST.dfsu file in the Data Manager, then select the *bed level change* item and Edit -> Calculator

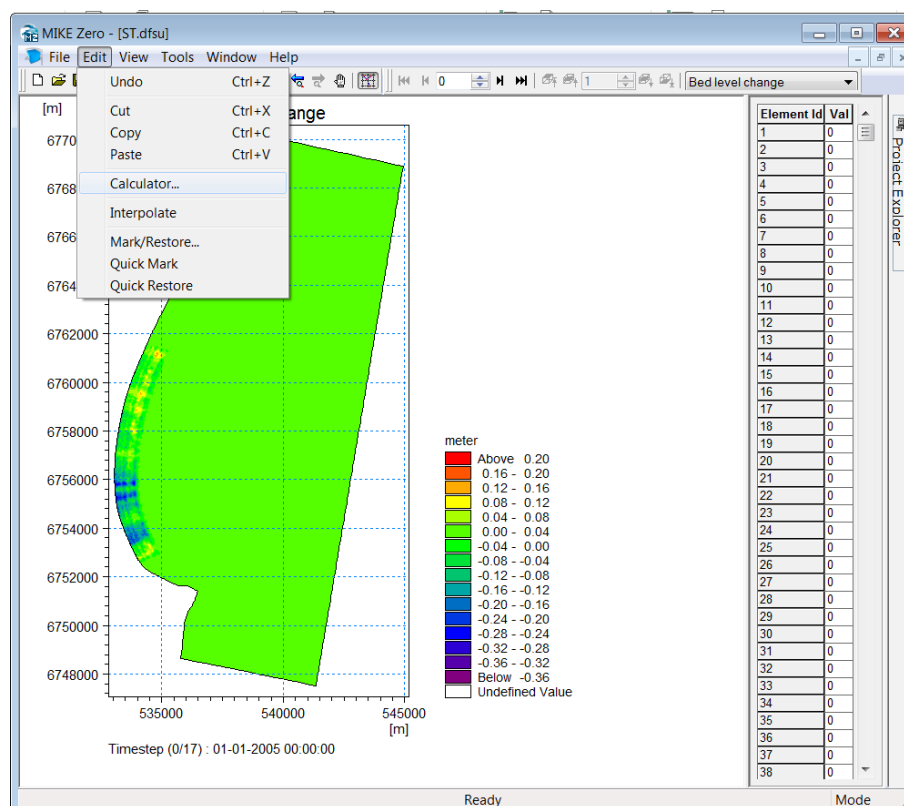


Figure 5.22 Select Edit and Calculator in the Data Manager

Now add a new variable (Figure 5.23) and select the file with the initial bed level change, which we just extracted (Figure 5.24).

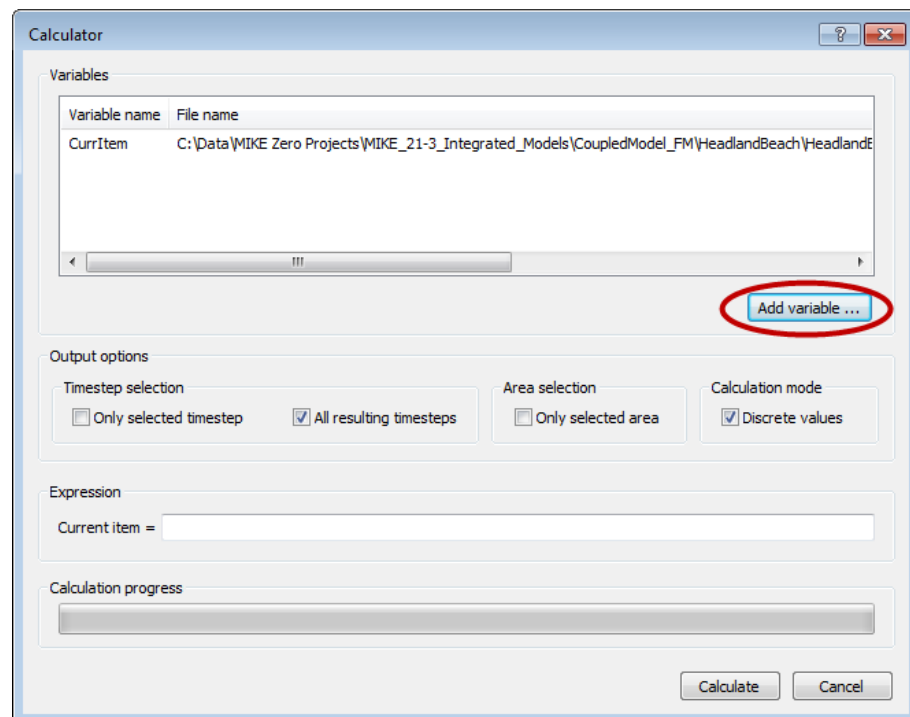


Figure 5.23 Add new variable

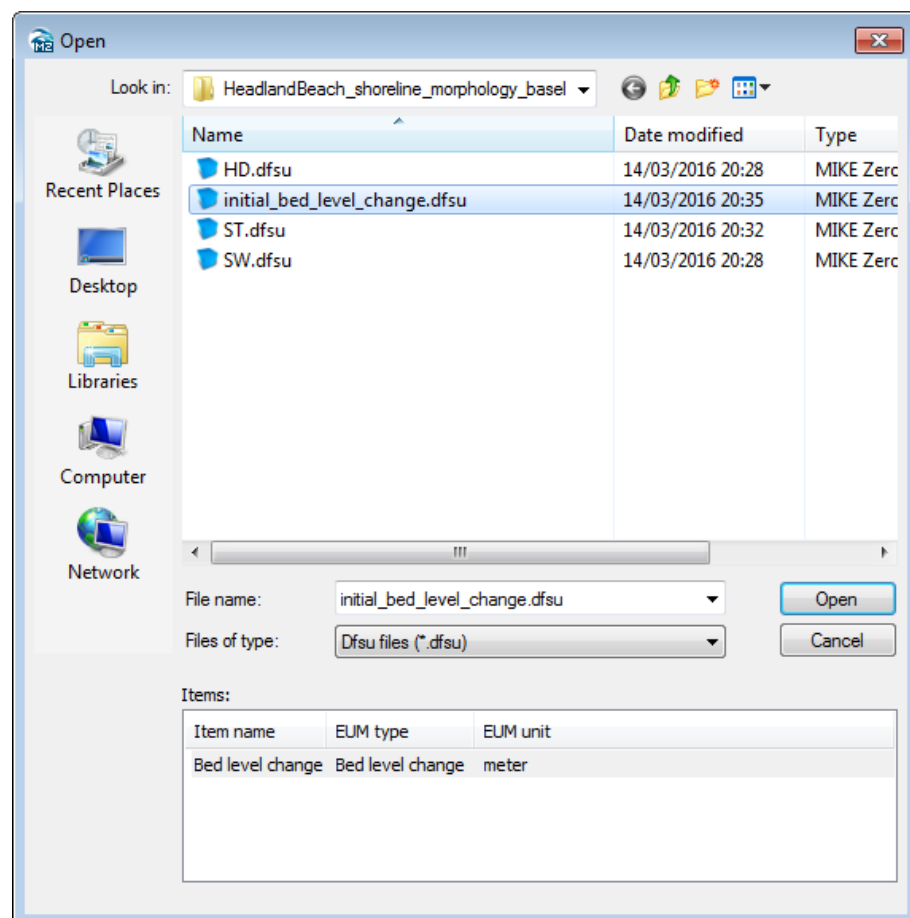


Figure 5.24 Select the initial bed level change

Now type the expression for the current item as shown in Figure 5.25 and press Calculate.

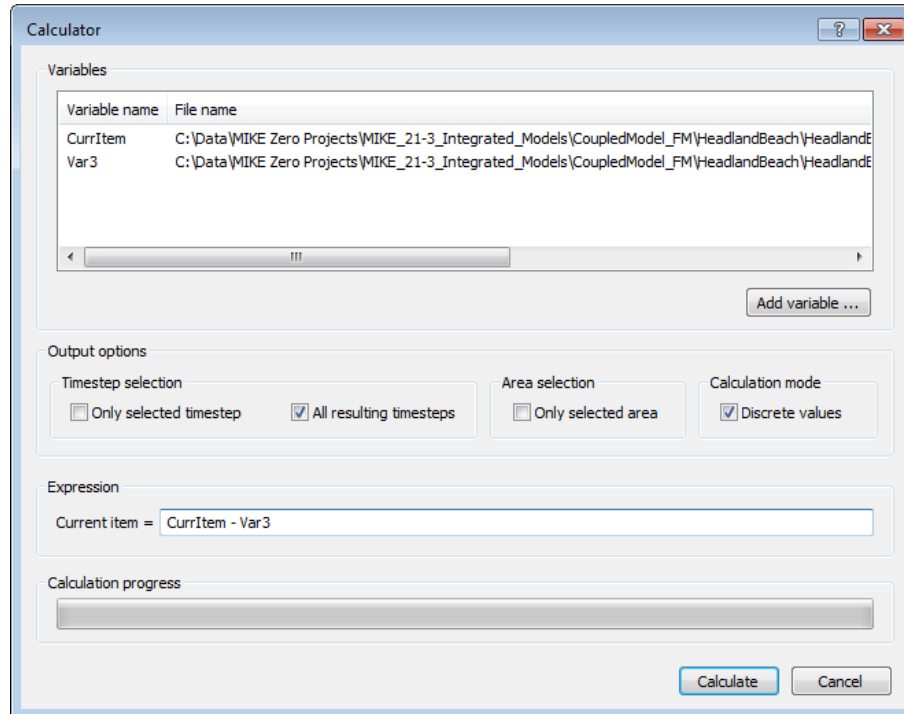


Figure 5.25 Type expression for Current item

Save the file, close Data Manager and open the file in Data Viewer.

The bed level change in the first and last time step should now look as shown in Figure 5.26. Note that the baseline.xyz file has been loaded using Right Click -> Add/Remove layers -> xyz file -> Edit -> XYZ Frame and Value (see Figure 5.27). So we can see that the area with the worst erosion is between baseline nodes 29 and 37 in agreement with Figure 5.19.



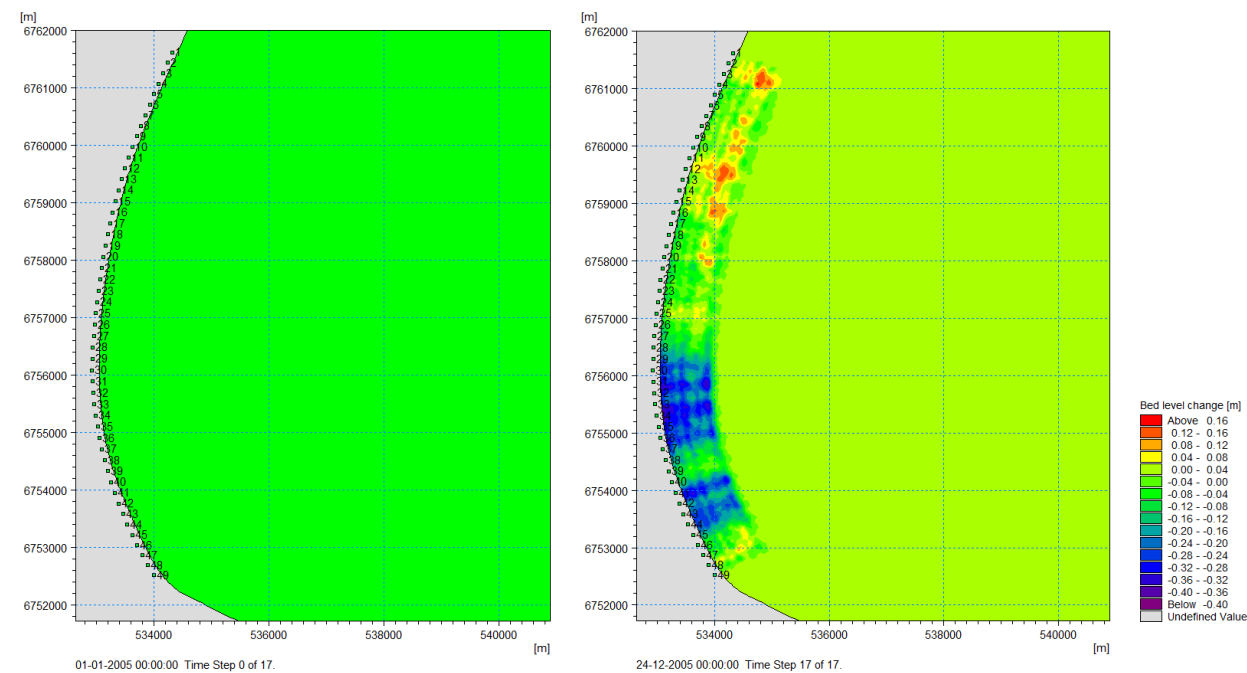


Figure 5.26 Initial (left) and final (right) bed level change after removing the initial bed level changes

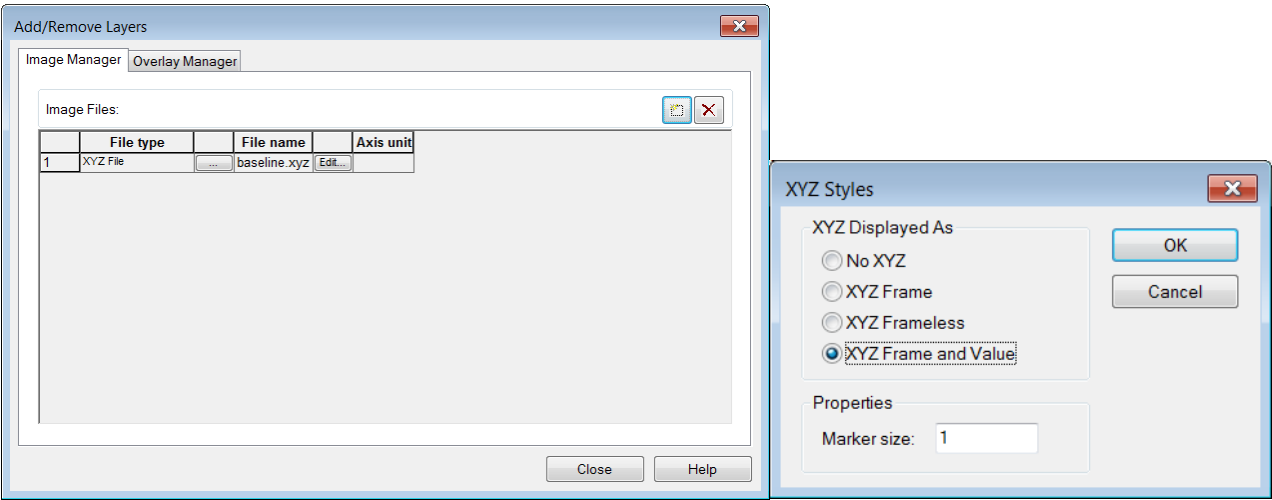


Figure 5.27 Add/Remove layers in Data Viewer



## 6 Breakwater Scenario

In this section we will add an off-shore breakwater to protect the area undergoing erosion in the baseline case.

The offshore breakwater will be added to the model by adding a dyke structure in the HD model and a line structure with the same geometry in the SW model.

The breakwater should be positioned such that the salient expected to form in the lee of the breakwater is located in the area experiencing the worst erosion in the baseline case.

### 6.1 Setup and Run the Shoreline Morphology Model

The starting point is the baseline setup:

[HeadlandBeach\\_shoreline\\_morphology\\_baseline.mfm](#). Save the file under a new name: [HeadlandBeach\\_shoreline\\_morphology\\_breakwater.mfm](#); then add a dike in the Hydrodynamic module by right clicking in the dikes section as shown in Figure 6.1.

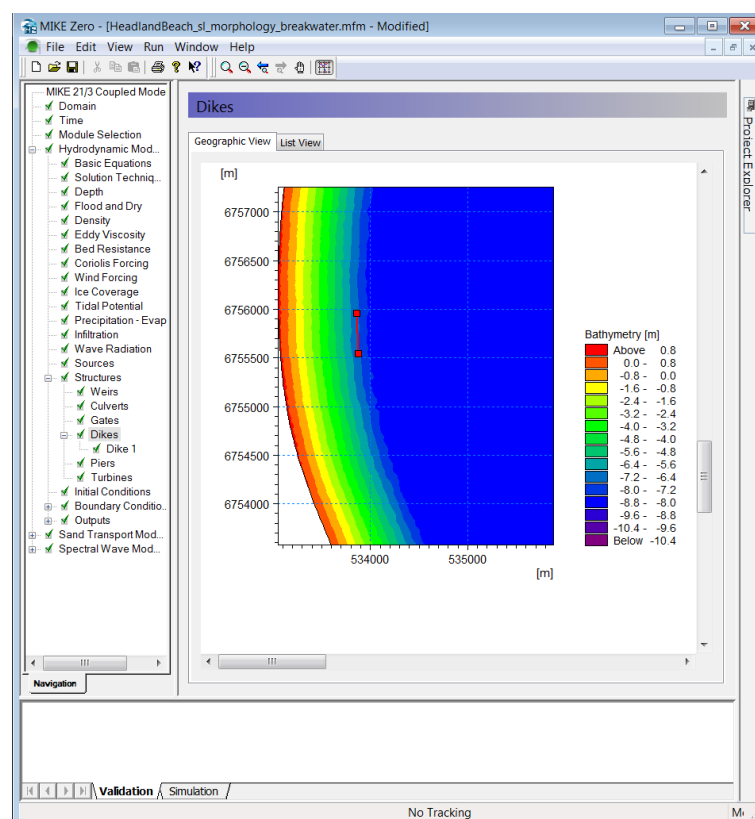


Figure 6.1 Add a new dyke in the hydrodynamic module

Next, set the overtopping to zero and copy the geometry of the dike as shown in Figure 6.3 and Figure 6.3, respectively.

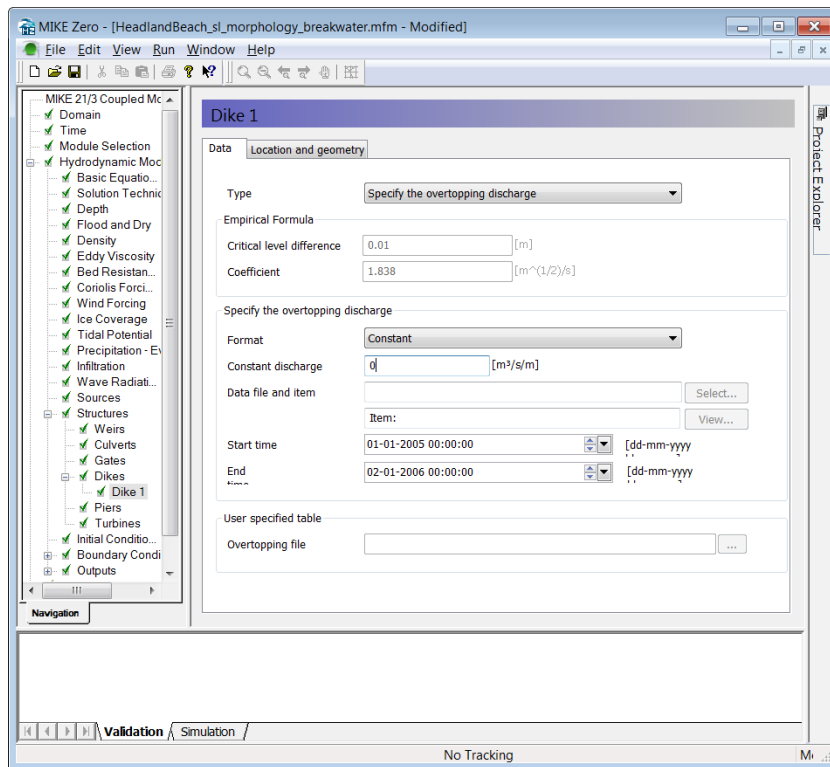


Figure 6.2 Set the overtopping discharge to zero

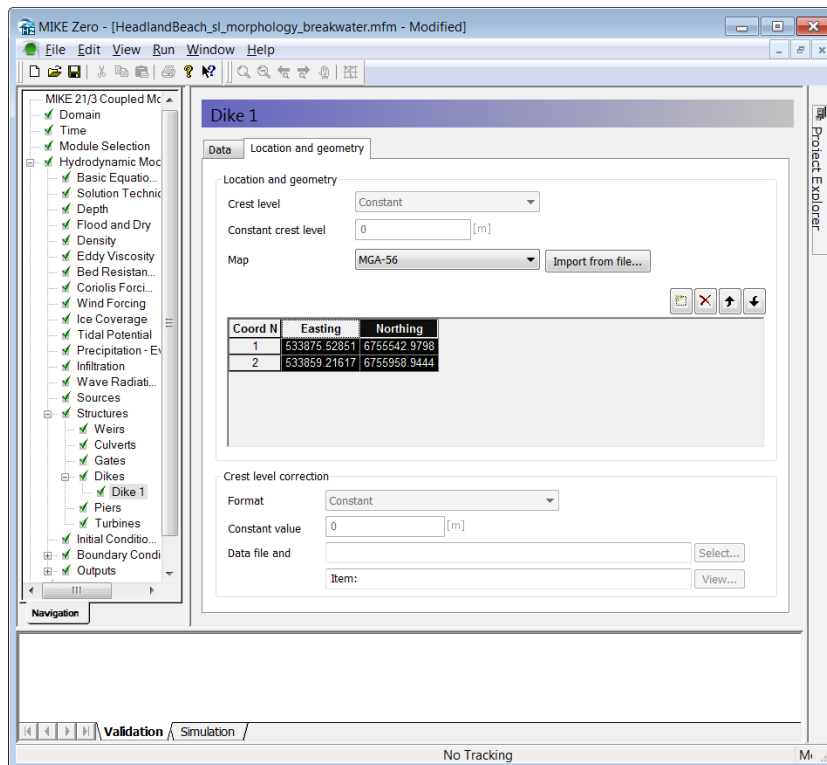


Figure 6.3 Define the geometry of the dike

Copy and paste the copied coordinates from Figure 6.3 into a text file in your favourite text editor, so it can be used for creating a line structure in the SW module. Then add a zero on both lines and save the file as breakwater\_points.xyz, see Figure 6.4.

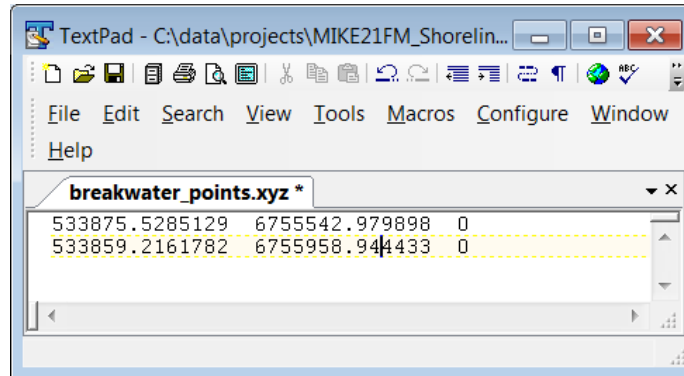


Figure 6.4 Create a xyz file with the coordinates of the breakwater

Next, add a new line structure in the SW module and add two points on the geometry page of the new line structure, make sure the coordinate system is correct. Then paste the geometry copied from the dyke to the line structure as shown in Figure 6.5, or load the geometry from the breakwater\_points.xyz file.

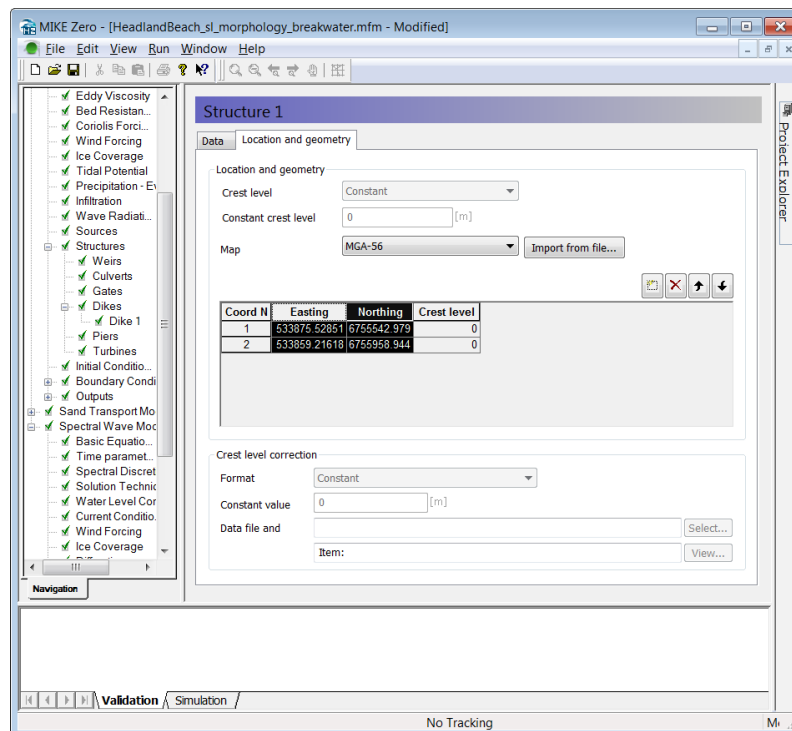


Figure 6.5 Paste the geometry of the dyke to the new line structure in the SW module

Now set the reflection and the transmission coefficients of the line structure to zero as shown in Figure 6.6.

We have now inserted an offshore breakwater in our Shoreline Morphology model, so we will run the model and look at the results.

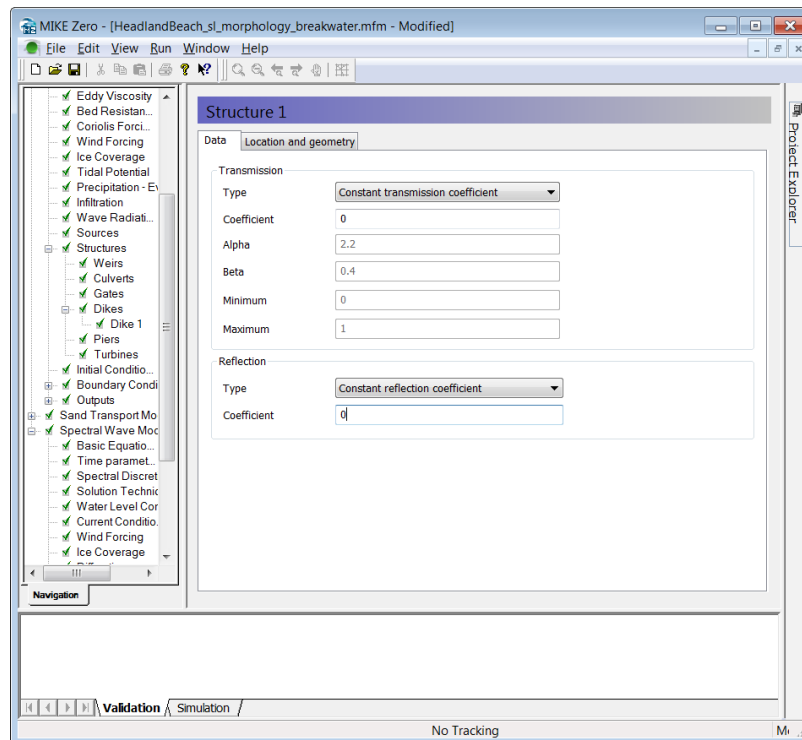


Figure 6.6 Set the transmission and reflection coefficients to zero for the line structure

## 6.2 Results

First, let us look at the effect of the line structure on the wave field. Open the SW output and add the breakwater\_points.xyz and the baseline.xyz files by right clicking and using *Add/Remove Layers* so we can see where the breakwater and baseline nodes are located; then do the same for the HD and ST results. Remove the initial bed level changes from the bed level change item in the ST file as explained in Section 5.5.

Figure 6.7 shows the effect of the breakwater on the wave height, current speed, sediment transport and bed level changes. It is noted that the wave height is greatly reduced in the lee of the breakwater, in this zone the current speed is also reduced as is the sediment transport. This cause a salient to form in the lee of the breakwater accompanied by down-drift erosion as seen the bottom right panel.

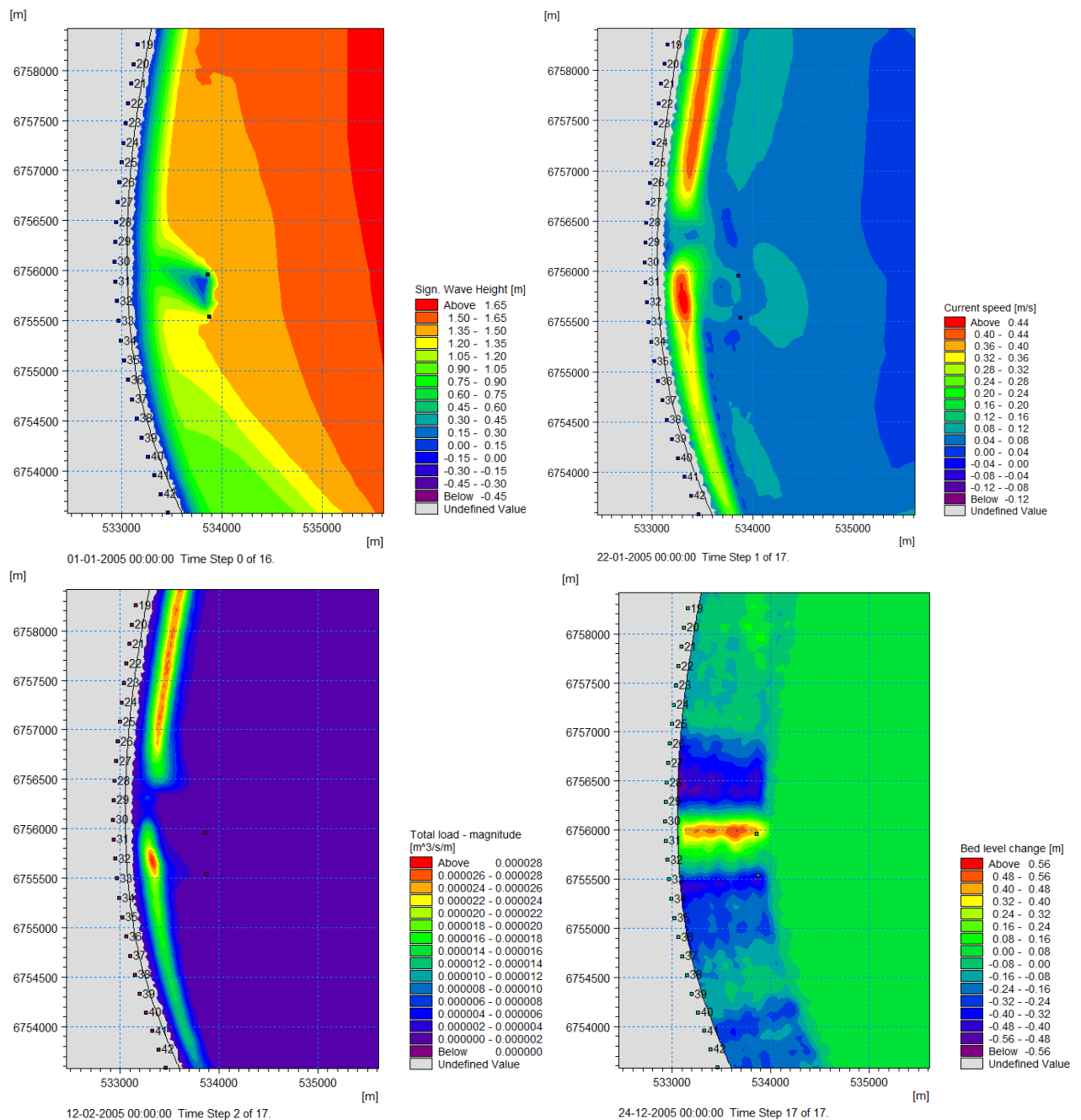


Figure 6.7: Effect of the breakwater on the wave height field (top left), current field (top right), sediment transport field (bottom left) and change in bed level (bottom right). Note that the initial bed level change has been removed as explained in Section 5.3

Figure 6.8 compares the accumulated change in shoreline position for the baseline case and the breakwater case. It is seen that a large salient (~50 m wide) forms in the lee of the breakwater, accompanied by down-drift erosion of around 35 m. Compared with the existing conditions the impact of the breakwater is much larger; it would probably be a good idea to make the breakwater smaller to reduce the impact.

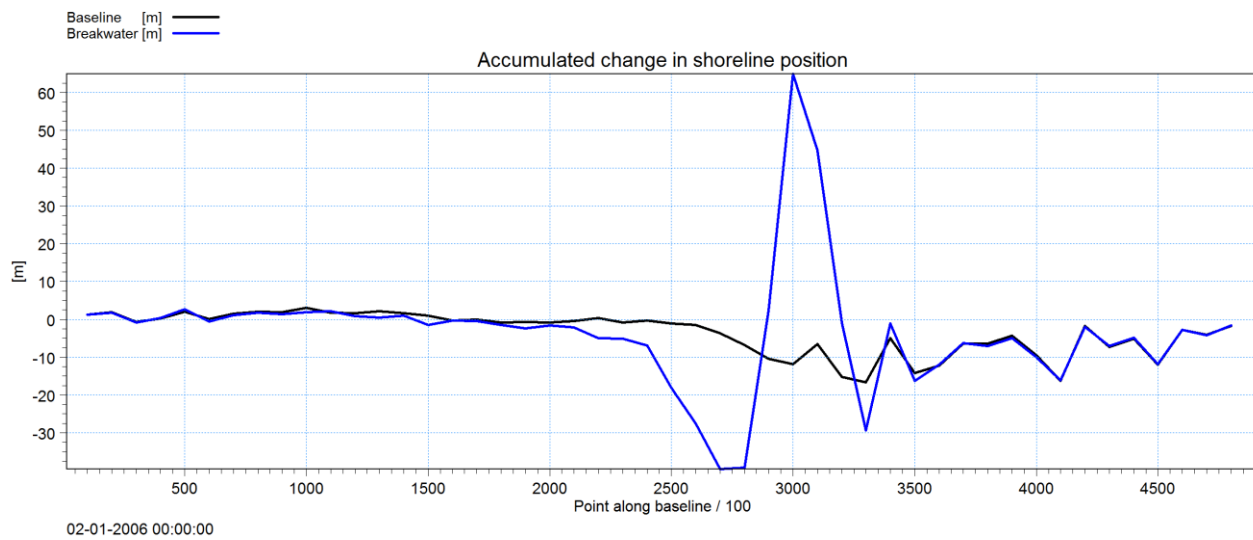


Figure 6.8: Comparison of the accumulated change in shoreline position along the shoreline



## 7 Further Exercises

It is quite easy to test other mitigation schemes such as groynes or artificial headlands in the Shoreline Morphology model. Simply add the structure in both the HD and the SW module and run the model; examples are shown in Figure 7.1 and Figure 7.2, respectively. These setup files are located in the example folder.

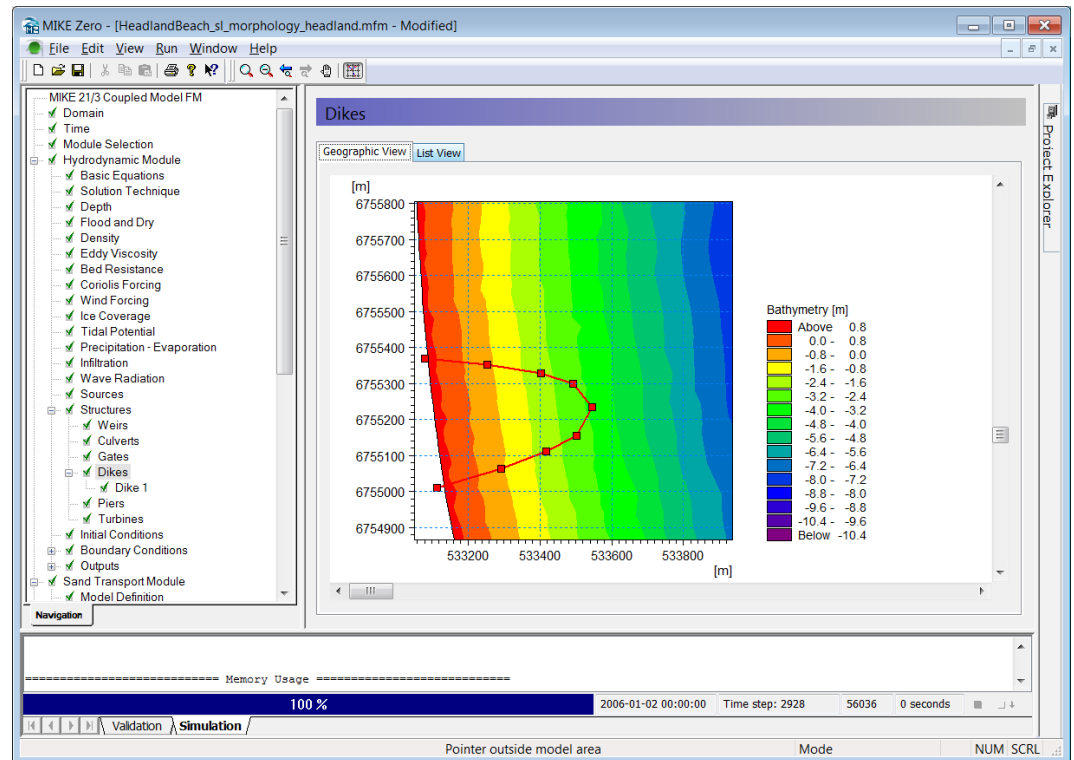


Figure 7.1 Example of an artificial headland

In MIKE 2017 it is now possible to illustrate simulated shoreline positions in MIKE Result Viewer. This is done by reading in the coastline.dfs1 file and selecting to show the coastline in xy-space. It is thereby possible to compare different simulations as is done in Figure 7.3.

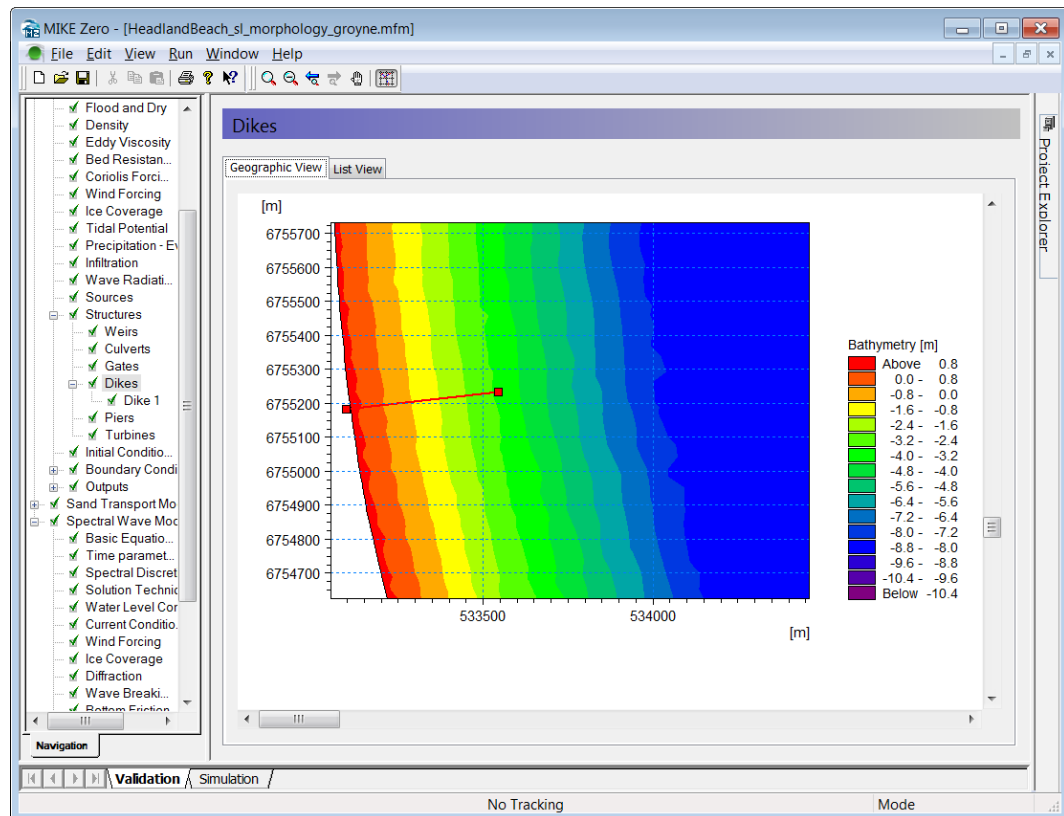


Figure 7.2 Example of an artificial groyne added to the model

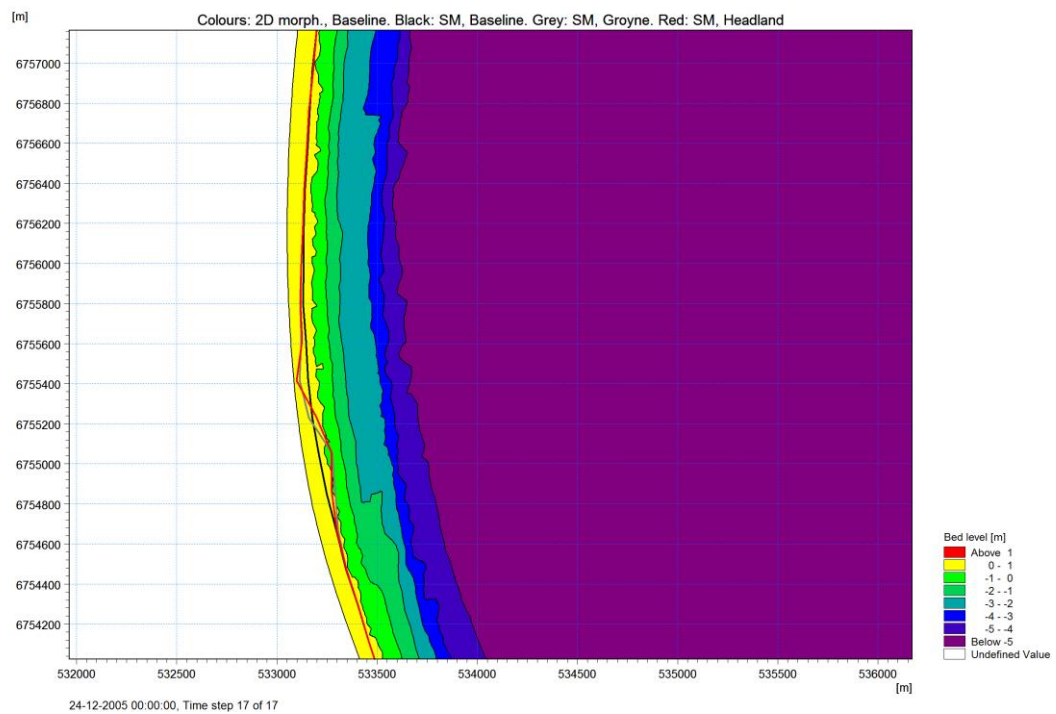


Figure 7.3 Comparison of simulated shorelines for three different cases in MIKE 21 SM FM. The colours show the simulated 2D response for the case without structures (standard morphology)