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GENERATING A MESH TO DETERMINE THE BATHYMETRY IN THE HARBOUR

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Abstract : In this paper we present the steps to determine the bathymetry in the harbour. For this we can use software MIKE Zero to create various meshes, each designed to apply for a special modelling task. The bathymetry mesh is created from scratch and optimised to a satisfactory .
Key words : coastal engineering, application, MIKE Zero, bathymetry, mesh, data, map.

1. INTRODUCTION

Coastal engineers are often interdisciplinary involved in integrated coastal zone management, also because of their specific knowledge of the hydro- and morph-dynamics of the coastal system. This may include providing input and technology for e.g. environmental impact assessment, port development, strategies for coastal defence, land reclamation, offshore wind farms and other energy-production facilities, etc.

Engineers will need to design coastal and offshore structures with climate change adaptation in mind. Addressing this challenge requires a greater analysis of the vulnerabilities of existing coastal and offshore structures, including a consideration of potential drivers and the circumstances contributing to more frequent structural failures and the loss of system functionalities and developing robust climate risk management strategies for building and improving the resilience of assets.

Climate change generates impacts on the environment, particularly in vulnerable systems like coasts, which are exposed to sea level rise. Moreover, potential changes in wind and atmospheric pressure patterns will modify hydrodynamic processes like storm surge and wave climate, which are fundamental driving terms on the coast

“The world’s coastal areas represent only 20% of the available land but host between 40% and more than half of the global population (Burke et al. 2001) [1]. No single definition can encompass the complexity of coasts, and the demarcation of coastal boundaries is no easy matter, for coastal areas are complex systems composed by a range of terrestrial, intertidal, and marine environments with seaward and landward zones of influence that stretch far inland and out to sea.

Different countries use different definitions and boundaries for coastal zones variably based on a combination of ecological, geographical, socioeconomic, historical, political, administrative, and legislative reasons [2]. While certainly informed by the ecological and geophysical characteristics of the coasts, these definitions are very much determined by functional and management requirements.

Coastal areas have been centres of human activity throughout history and current trends indicate that migration toward these zones is continuing.

The main reason for this is that the rich variety of ecosystems and habitats in coastal zones provides a range of goods and services critical to human sustenance and well-being, particularly food production (e.g. fisheries and aquaculture), raw materials, and transportation options.

Coastal areas provide also other ecological and socioeconomic services with deep interrelations between them: erosion control of land and intertidal ecosystems (e.g. wetlands and salt marshes), storm protection, water purification, nutrient recycling, and recreation (tourism).

Due to their unique location, coastal areas are also at the receiving end of impacts coming both from the sea and from the land.

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Figure 1 Map of ECA region [2]

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This exposes coastal areas to the influences of climate change either directly (sea-level-rise, storm surges, floods, droughts) or indirectly through events that originate off-site but whose consequences propagate down to the coasts (river floods and changes in seasonality, pulses, quality of run-off)"(Figure 1)[2].

2. IMPORTANCE OF COASTAL AREAS

"Coastal areas are most often defined through a combination of physical-geographical and management criteria. However, this presents difficulties when trying to assess the socioeconomic or biodiversity conservation value of coastal areas through the use of global data. To overcome this limitation, coastal areas are commonly defined as: "intertidal and subtidal areas on and above the continental shelf […] areas routinely inundated by saltwater, and adjacent land, within 100 km from the shoreline" (Martinez et al. 2007).[3]
Using this definition, the social importance of the coastal areas in ECA basins is demonstrated by the percentage of population living within 100 kilometres of the coast (Figure 2 and Table 1). Albania and Estonia are small countries, which is why almost the entirety of their populations is included in this group.

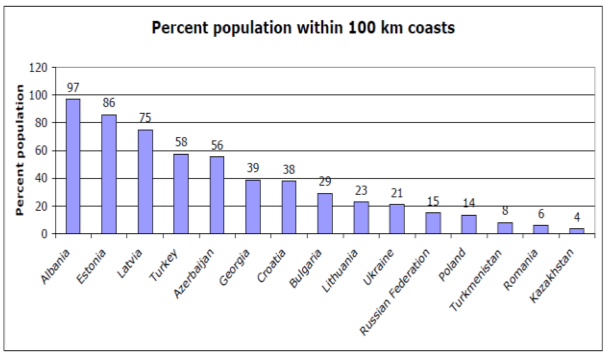

Figure 2 Percent of population living within 100 km from the coast. Twelve countries out of 15 have more than 10% of the total population located within 100 km of the coastline.[1]

Table 1. Percentage of total population living within 100 km of coastline – average per basin [4]

Sea[1]	Adriatic Sea2	Baltic Sea3	Black sea4	Caspian sea5
Average population	68%	49%	28%	21%

where
1 sea
2 Includes Croatia and Albania
3 Includes Estonia, Latvia, Lithuania, Poland
4 Includes Bulgaria, Romania, Georgia, Ukraine, Russian Federation, Turkey
5 Includes Azerbaijan, Turkmenistan, Kazakhstan, Russian Federation

2.1 Climate changes in coastal areas:

Climate change causes various impacts on ECA coastal areas through extreme weather events, long-term changing averages in climatic variables and increased weather variability. Sudden severe phenomena such as storm surges, and gradual changes like SLR, will directly affect human well-being by damaging investments and infrastructures, and indirectly through modification of coastal ecosystems and habitats (Alcamo et al. 2007)[4]. Although climate change may offer positive opportunities as well as cause harm, it is expected that the latter will far outweigh the former. Furthermore, the IPCC reports that for the first decades of the 21st century some of these events will be heavily influenced by the North Atlantic Oscillation (NAO).

According to several models these impacts would become most significant after 2050 (Alcamo et al. 2007)[4]. However, two aspects must be considered: (1) several observations indicate that climate change may be more dramatic than predicted (see glacier melt section), (2) coastal exposure to climate change can vary greatly according to interactions between global, regional, and local weather and bio geophysical factors. The rate of sea level- rise is influenced by cyclical regional weather patterns, local atmospheric pressure, sea thermal expansion, coast subsidence, uplift caused by tectonic movements, and other hydrogeological factors (Nicholls et al. 2007; Nicholls and Klein)[5]. While the IPCC projects Special Report Emission Scenarios (SRES) indicating a global SLR of between 0.09 to 0.88 meters by 2100, in Europe the interaction with local factors may induce a SLR that could be 50% greater than the global estimates (Alcamo et al. 2007)[4].

Given the uncertainty of current estimates, it is critical that an adaptation strategy be put into action in ECA. Adaptation to climate change in the context of coastal areas is defined as a policy process entailing

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decisions on policy and technological interventions that aim at reducing the vulnerability of the system to climatic changes. This section follows the general approach of the Umbrella Report in defining vulnerability as a function of exposure to climate change, sensitivity of the system, and adaptive capacity (Figure 3)[5].

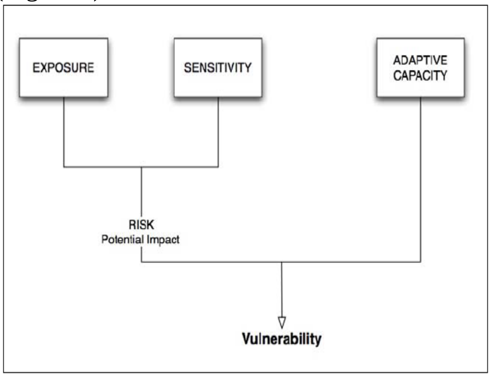

Figure 3 Vulnerability as a function of exposure, sensitivity, and adaptive capacity [5]

In order to reduce the vulnerability of coastal areas to climate change it is therefore necessary to examine the exposure to climate change of the basins of interest, their sensitivity to the changes, the adaptive capacity and other factors that may influence these components.

2.2 The economic dimension of coastal areas :

Establishing the relevance of coastal areas to the economy of a country is a more complex exercise. Fisheries do not constitute a great share of GDP in ECA basins. Fishery landings within a country EEZ [4] account for less than one percent of the GDP. Buys et al. (2007) examined a subgroup of ECA coastal countries and suggest that a SLR of one, two, or three meters would only affect between 0.13% and 1.99% of a country's GDP (Table 1.3). Georgia and Ukraine are predicted to be the worst off, followed by Estonia. Bulgaria and Romania are predicted to be the best off.

3. GENERATING A MESH TO DETERMINE THE BATHYMETRY IN THE HARBOUR

3.1 Mathematical modelling IN MIKE

Mike by DHI is a software dedicated to the management of waters. This software has a variety of components, but the one we will be using is MIKE 21 Flow Model – which provides the basis for process calculations, performed in many other modules such as sediment and mud transport, thermal energy and suspended solids transport, oil spill, agent-based modelling and ecology, but it can also be used as standalone application. The module simulates the inconsistent flow taking into account the bathymetry, the sources and the external forces. With the help of this model, we will eventually evaluate the hydrographic conditions of the work area [6].

Creating a mesh is a very important step in terms of modelling with the help of the MIKE by DHI software. This file contains information about: grid calculation, water depths in various areas and extreme conditions.

3.2 Mesh Generator

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The objective of this Step-by-step training guide is to use the Mesh Generator to create various meshes, each designed to apply for a special modelling task. The bathymetry mesh is created from scratch and optimised to a satisfactory level (Figure 4)[6].

Figure 4 A harbour which is located on the west coast of Denmark

- *Step one-creating a mesh*

For this application, it used a file provided with the installation of the MIKE Zero program, which contains information about

- water depths
- computational grid
- boundary information of the harbor (Figure 5).

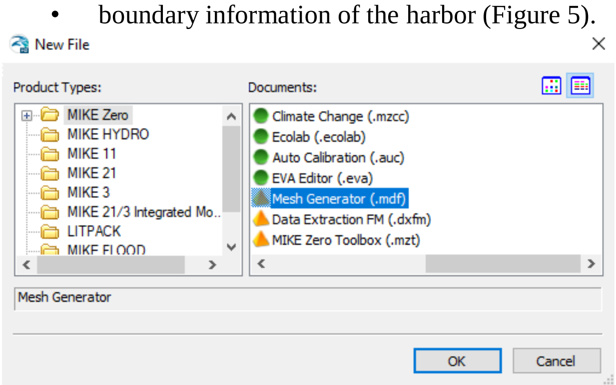

Figure 5 Program selection

The mesh file couples water depths with different geographical positions (File -> New File -> Mesh Generator (.mdf)

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After starting the Mesh Generator, we specified the projection system as UTM and the zone as 32 for the working area, as indicated (Figure 6).

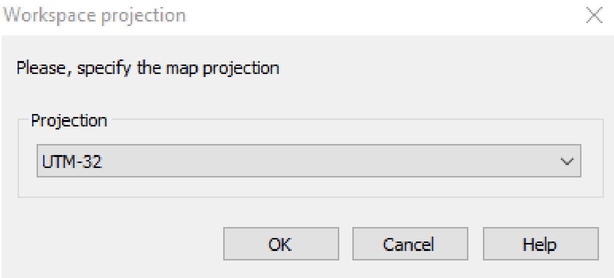

Figure 6 Defining the projection of the workspace

- *Step two- modifying boundary conditions with an area that can be triangulated*

In order to evaluate the outline of the model area it were imported all the available Scatter Data (*Data -> Manage Scatter Data -> Add*).

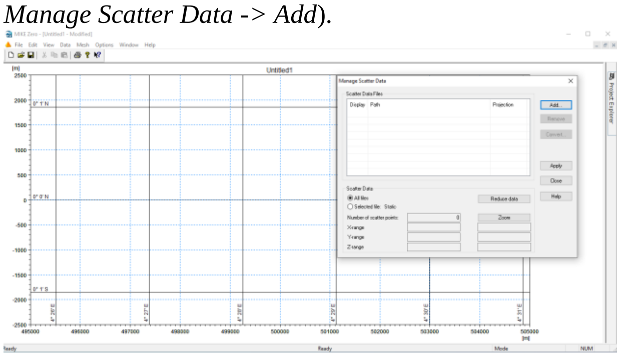

Figure 7 Informations about bathymetry

For this application, it was chose the file that will reveal information about the bathymetry of the studied harbor (Figure 7)..

The bathymetry is usually interpolated from xyz Scatter Data holding a water depth value (Figure 8).

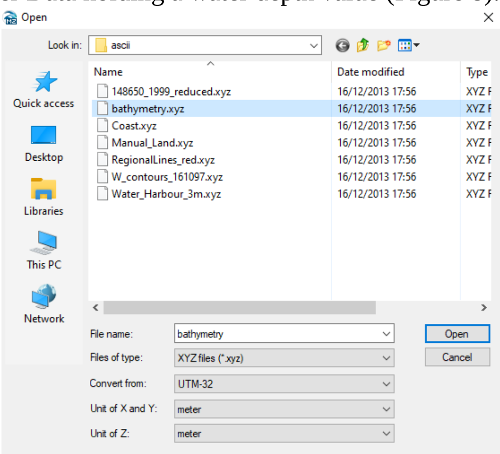

Figure 8 The bathymetry xyz interpolation

These are typically found from measurements, surveys, digitization of maps or exported from MIKE C-MAP.

The steps are: *Data -> Manage Scatter Data -> Add -> bathymetry.xyz -> Apply*.

- *Step three*

After importing Scatter Data, the workspace is revealed.

The mesh file containing information about water depths and mesh is created with the Mesh Generator Tool in MIKE Zero (Figure 9).

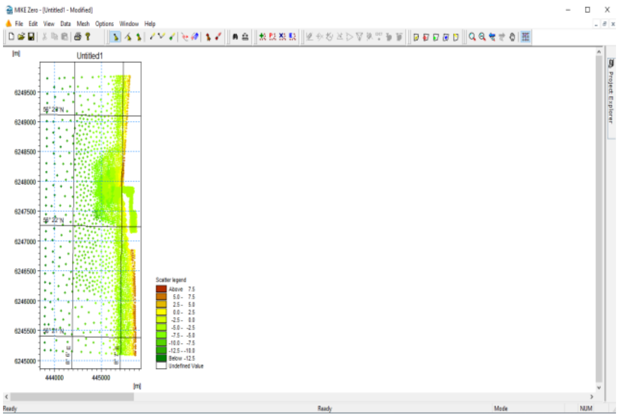

Figure 9 View -> Zoom to Extend of Data

The water depths in the nearshore area are well defined by surveys while in the regional area the bathymetry is defined by navigational charts.

- *Step four*

For this step were created boundaries around the areas of interest by using the draw arc tool from the toolbar (Figure 10, Figure 11).

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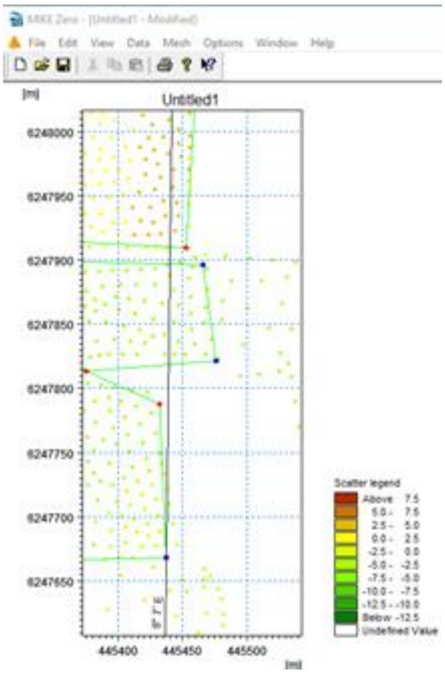

Figure 10 Boundaries around the areas of interest

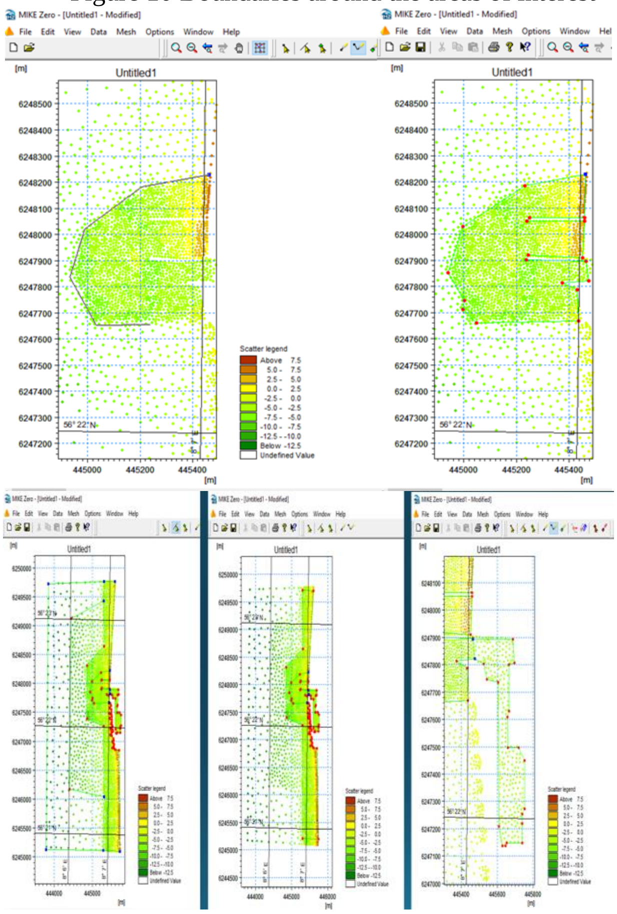

Figure 11 Final created boundaries

- *Step five*

Select the arcs created previously with the select arcs tool and go to properties to change the arc properties (Figure 12).

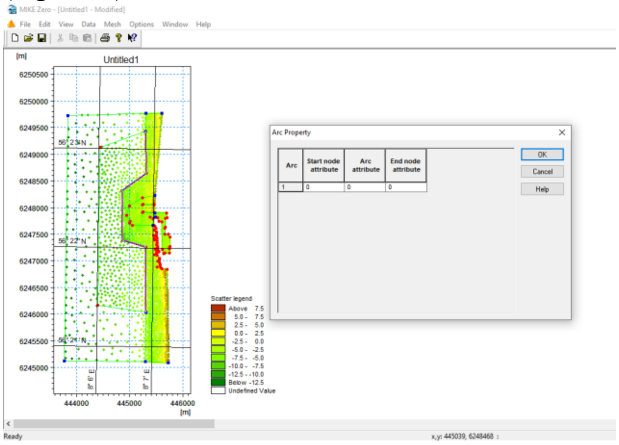

Figure 12 Arc property

The node points and arcs on the open boundaries must be defined by a unique integer value. These attributes are used for the model system to distinguish between the different boundary types in the mesh:

- Attributes equal to 2 and above correspond to open boundaries
- Attributes equal to 1 correspond to land/water boundaries.

- *Step six-triangulation*

The next step is to triangulate the domain. For this, it was selected each shape defined previously and it was used the Insert polygon tool to define the areas that are about to be triangulated.
Go to Data -> View Scatter Data to get a different view of your workspace (Figure 13).

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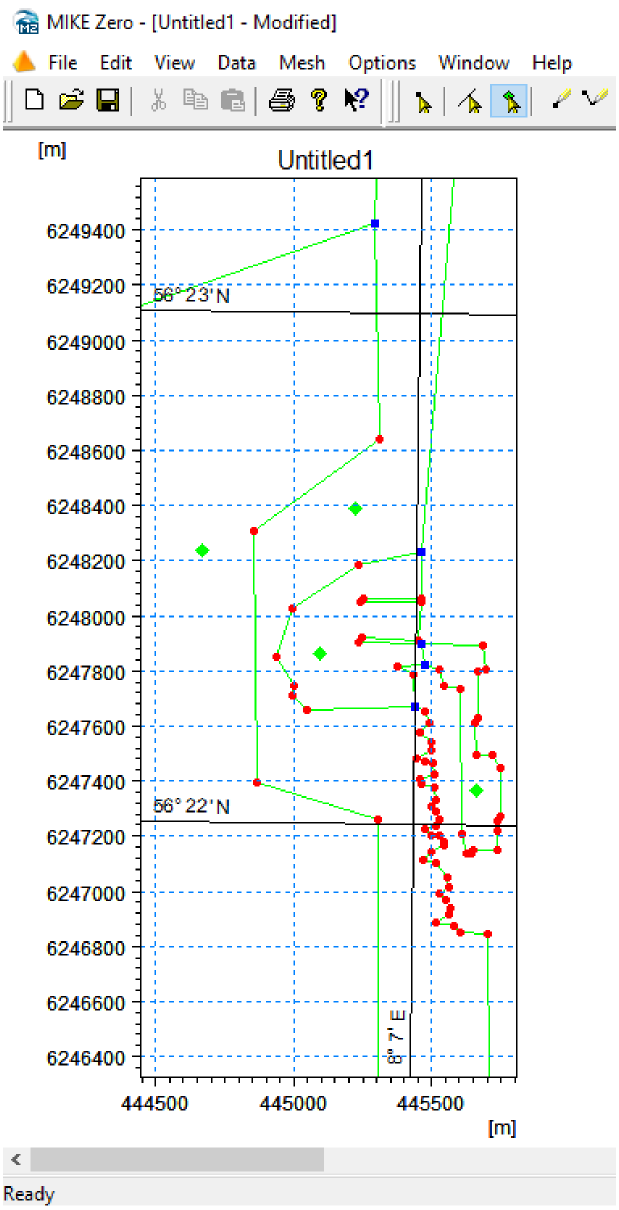

Figure 13 Triangulation of the field of study

Go to Insert polygon tool -> click on each shaped defined previously (a green dot will appear).

- *Step seven*

Right click into the polygon (green dot) -> *go to properties -> Select apply triangular mesh*.

The triangulation is used to determine the position of points spread over an area.

Check the "*Use local maximum area*" box and insert maximum area values for each shape that will be triangulated.

For this example it used a maximum area of:

- 20.000 for the first polygon
- 10.000 for the second polygon
- 1000 for the third polygon
- 500 for the forth and fifth polygon (Figure 14).

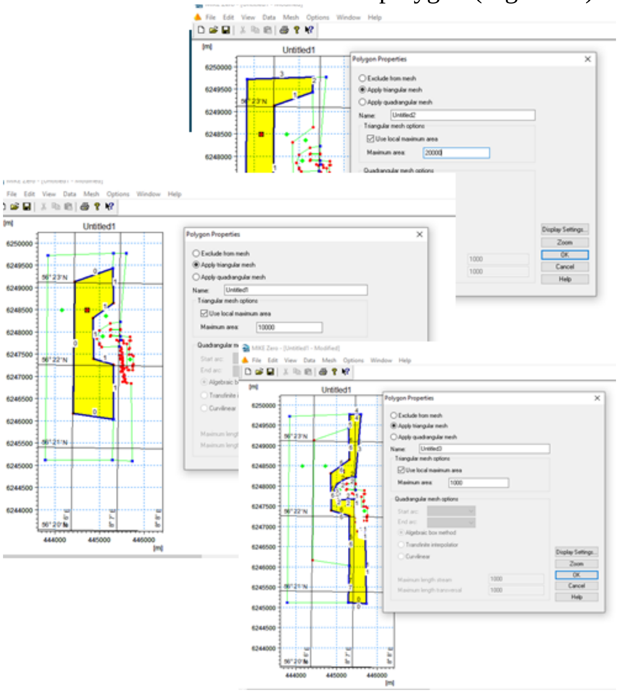

Figure 14 The determination of position of points spread over an area

- *Step eight*

Go to Mesh -> Generate Mesh to make the first triangulation and then use the triangulation option setting as shown in the image below (Figure 15).

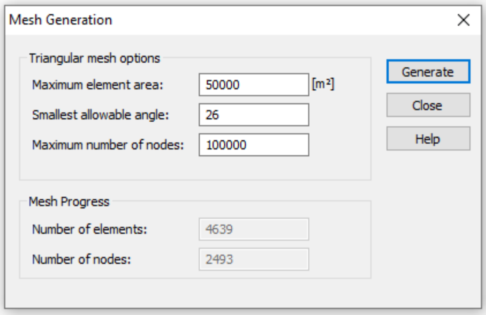

Figure 15 Mesh generation

Elements limited by boundary point positions tend to be much smaller than elements only limited by maximum element area.

After the triangulation you can use a tool for smoothing the mesh (Figure 16).

Go to Mesh -> Smooth Mesh

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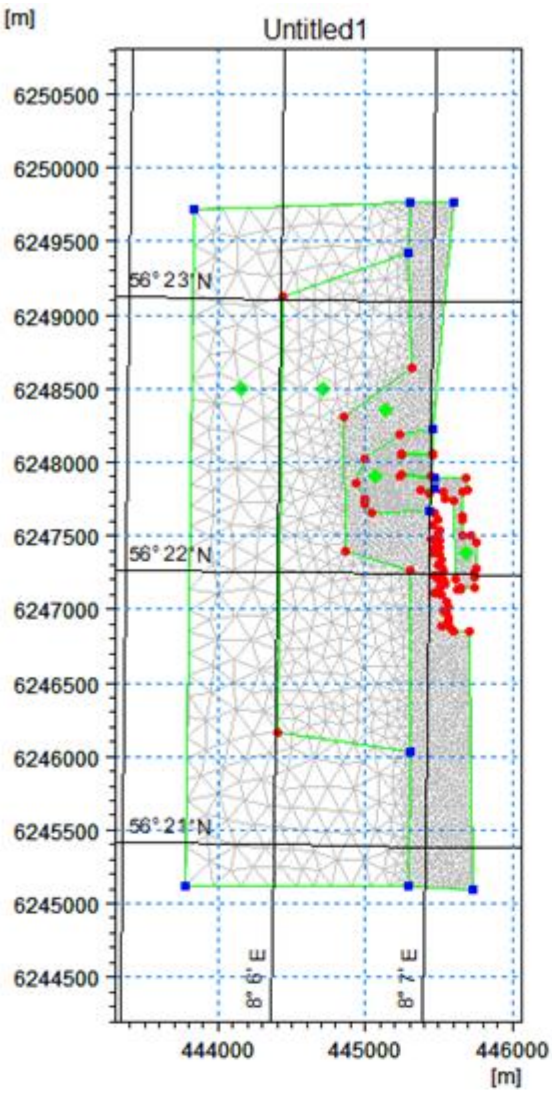

Figure 16 Smoothing the mesh

- *Step nine*

Go to Mesh -> Interpolate -> Start
The initial bathymetry is now created from the initial mesh by interpolating scatter data (Figure 17).

Interpolate the bathymetry values by using the default settings for the interpolation. (*Mesh -> Interpolate -> Start*).

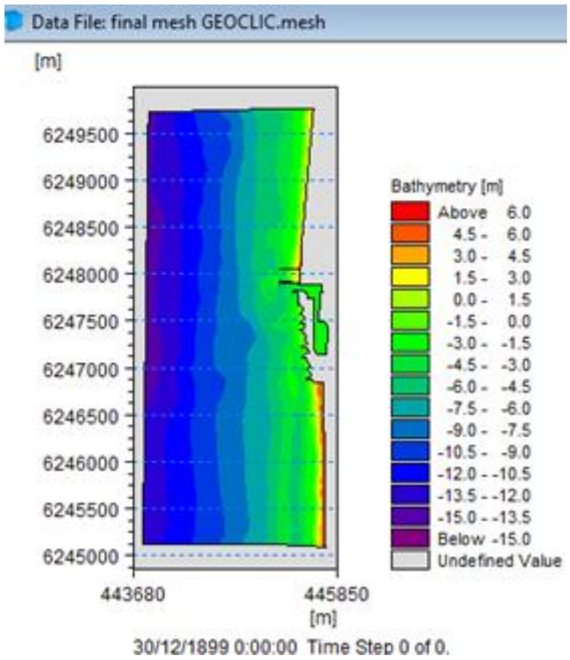

Figure 17 Initial bathymetry-interpolating scatter data

The resulting image will be the mesh as it appears in the Mesh Generator after interpolating water depth xyz data into the mesh.
The final mesh is now created (Figure 18).
Go to Mesh - > Export mesh

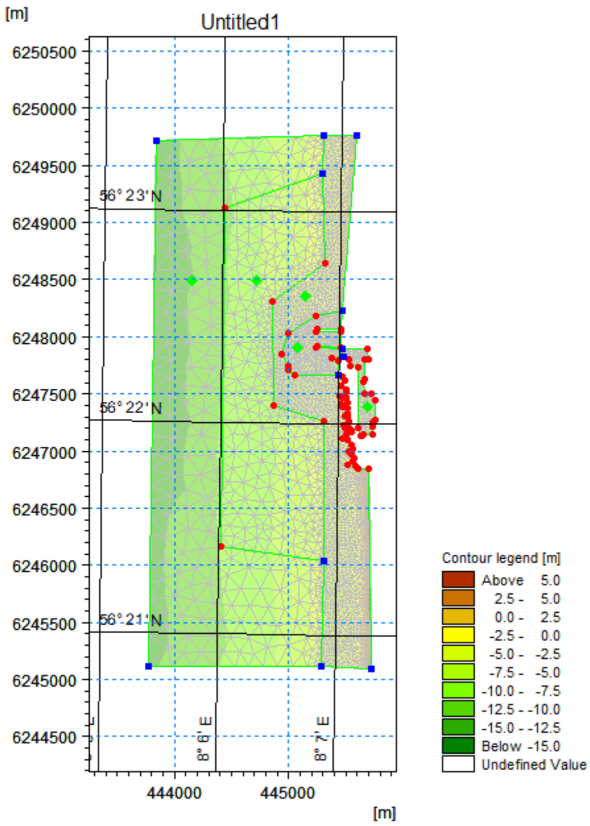

Figure 18 The final mesh

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4. CONCLUSIONS

Shoreline evolution can be natural or can be caused by the side effects of marine constructions, designed/artificial beaches and shoreline protection structures. Furthermore, climate change alters the base conditions under which coastlines evolve. In both cases, valid predictions of long-term shoreline movements are vital to mitigate or prepare for erosion and changes in coastal stability. Shoreline modelling addresses questions such as equilibrium shoreline, shoreline erosion and envelope (seasonal/event driven), sediment budget and so on.

The coastal profile included in the simulations may be specified by:

- a constant profile along the entire shoreline ;
- interpolation between a number of profiles ;
- direct extraction from a bathymetric survey.

The new shoreline model implements a flexible dynamic baseline, thereby allowing the model to be applied to problems with a curved coastline.

5. ACKNOWLEDGMENTS

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