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COASTAL EROSION AND FLOODING HAZARDS

ON THE NORTH SEA COAST AT THYBORON, DENMARK

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INTRODUCTION

Since a breach of the coastal barrier in 1862, the Thyboron Channel connecting the North Sea and the Lim Fiord has been artificially maintained by construction of breakwaters and groins on the North Sea coast and inside the channel, respectively. Sand nourishment schemes have since the 1980s counteracted the natural erosion in the upper profile on the North Sea coast where the alongshore sediment transport converges towards the channel and deposits up to 1 million m^3/y on the flood tidal delta inside the fiord, Figure 1.

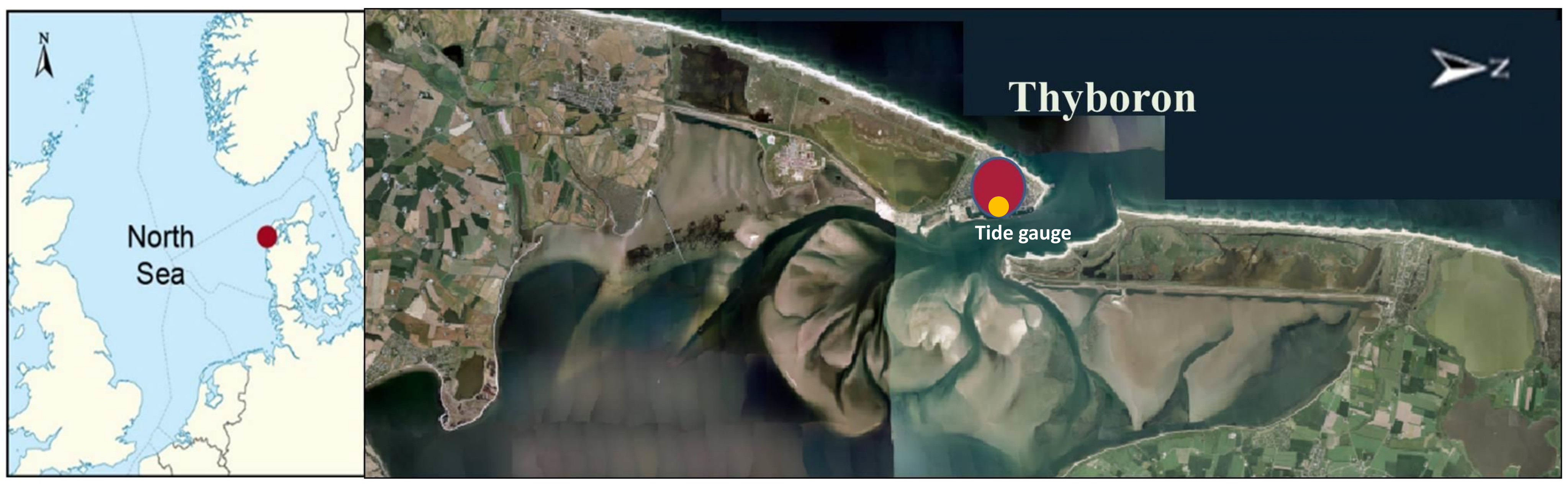

Figure 1. The Danish North Sea coast at Thyboron, the channel, and the flood tidal delta inside the Lim Fiord.

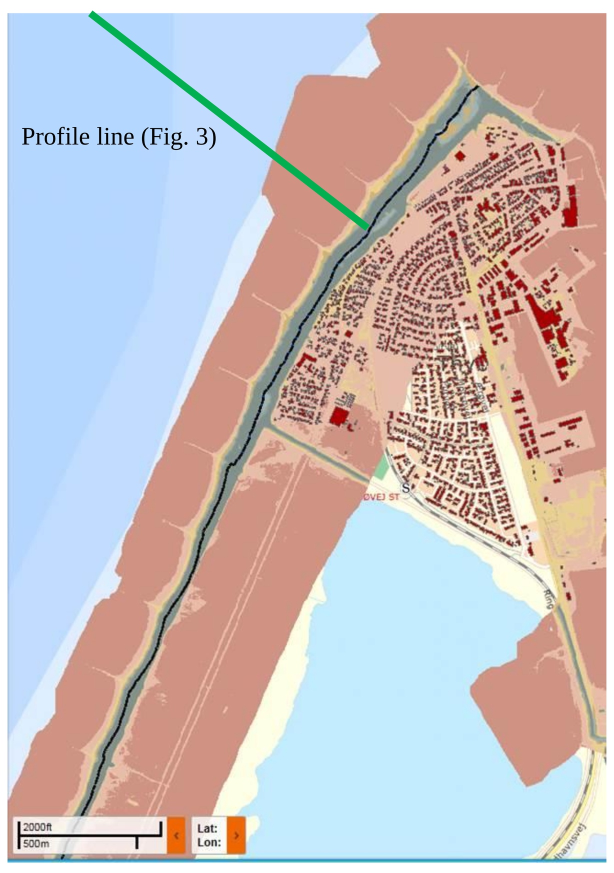

Figure 2. Small sandy barriers (green) provide safety. In black is the safety line. Flood prone areas in red and yellow.

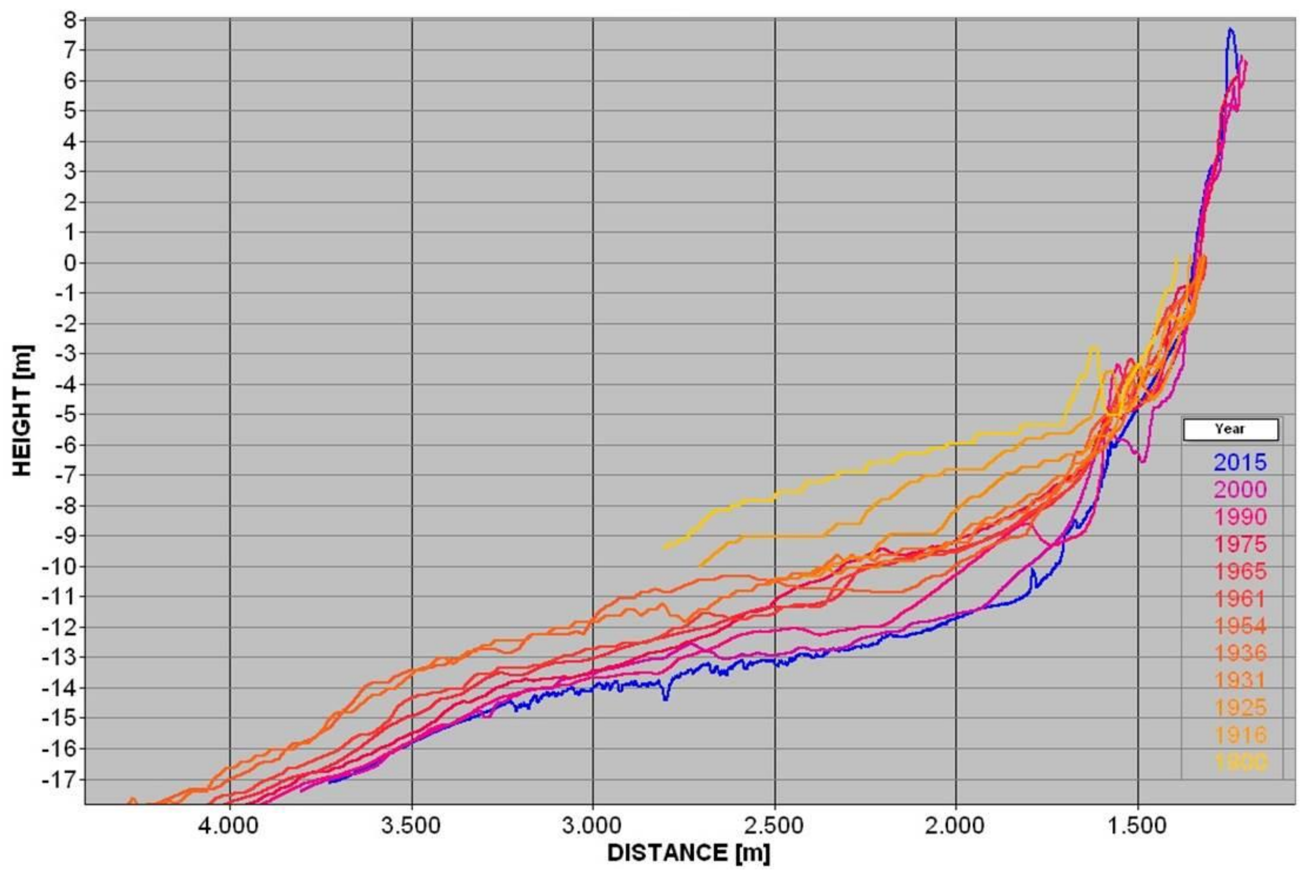

Figure 3. Coastal profile evolution, 1900-2015. The upper profile from -6 m DVR90 has been sand nourished since the late 1980's Profile line shown in Figure 2.

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The open coast still experiences net erosion in the lower parts of the profile, and Figure 2 shows the narrow sandy barrier which protects Thyboron from getting flooded. Each year the barriers on each side of the channel are is nourished with 500,000 m^3 of sand on average. This volume is sufficient to stop the retreat of the upper profile to -6 m DVR90. However, this amount has to be increased by 20 % until 2050 as the coastal steepening continues, Figure 3, to counteract the increased sand depletion of the upper profile.

In the navigation channel, the deeper part is expected to shift further eastward following the trend from 1958 to 2005. The navigation channel, which already has to be extensively dredged today, will experience an increased need for dredging ahead.

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The cross-sectional area of the channel is out of equilibrium with the tidal prism and increases; leading to more extreme storm surge levels inside the fiord, Figure 4. Furthermore, the town of Thyboron experiences a differentiated net land subsidence of 2-8 mm/y. The increased cross-section, land subsidence and climate changes together will increase the future flood risk in Thyboron significantly, Figure 5.

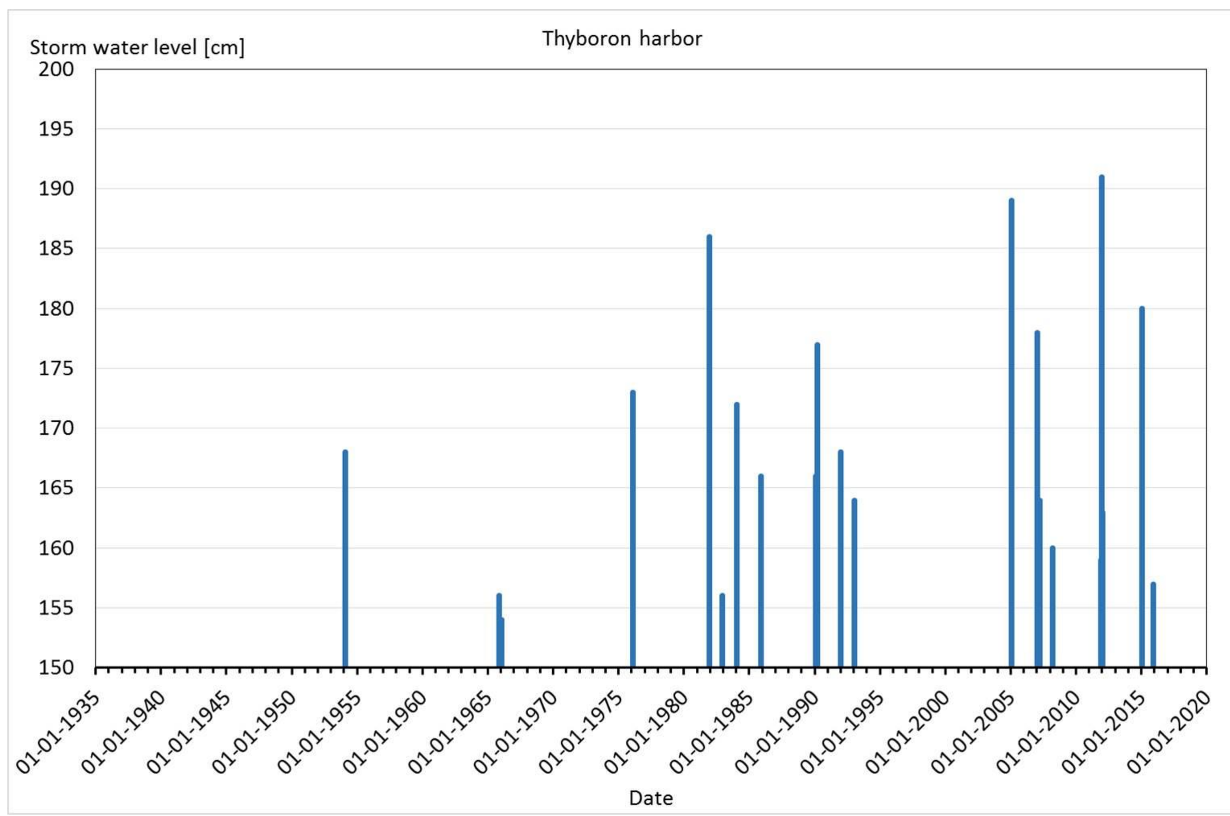

Figure 4. Heights of storm surge levels above 150 cm DVR90 at Thyboron Harbor tide gauge since 1935. Gauge position in Figure 1.

THE FUTURE

Eight different options to manage the erosion and flooding hazards in the future have been analyzed. The technically preferred option is to extend of one of the groins to reduce the cross-sectional area to reduce the net erosion rates on the barriers, to limit storm surge water levels, and to makes it easier to enter the navigation channel. A sluice solution has also been analyzed due mainly to environmental issues, Figure 6. A more detailed analysis work is still necessary, however, in order to effectively deal with the combined erosion and flood hazard challenges and to decide upon the optimal solution for the future protection of Thyboron and the Lim Fiord barriers.

Figure 5. Potential flooding extent from a storm surge at Thyboron Harbor with a return period of 50 years in 2016 (left) and in 2060 including sea level rise and land subsidence.

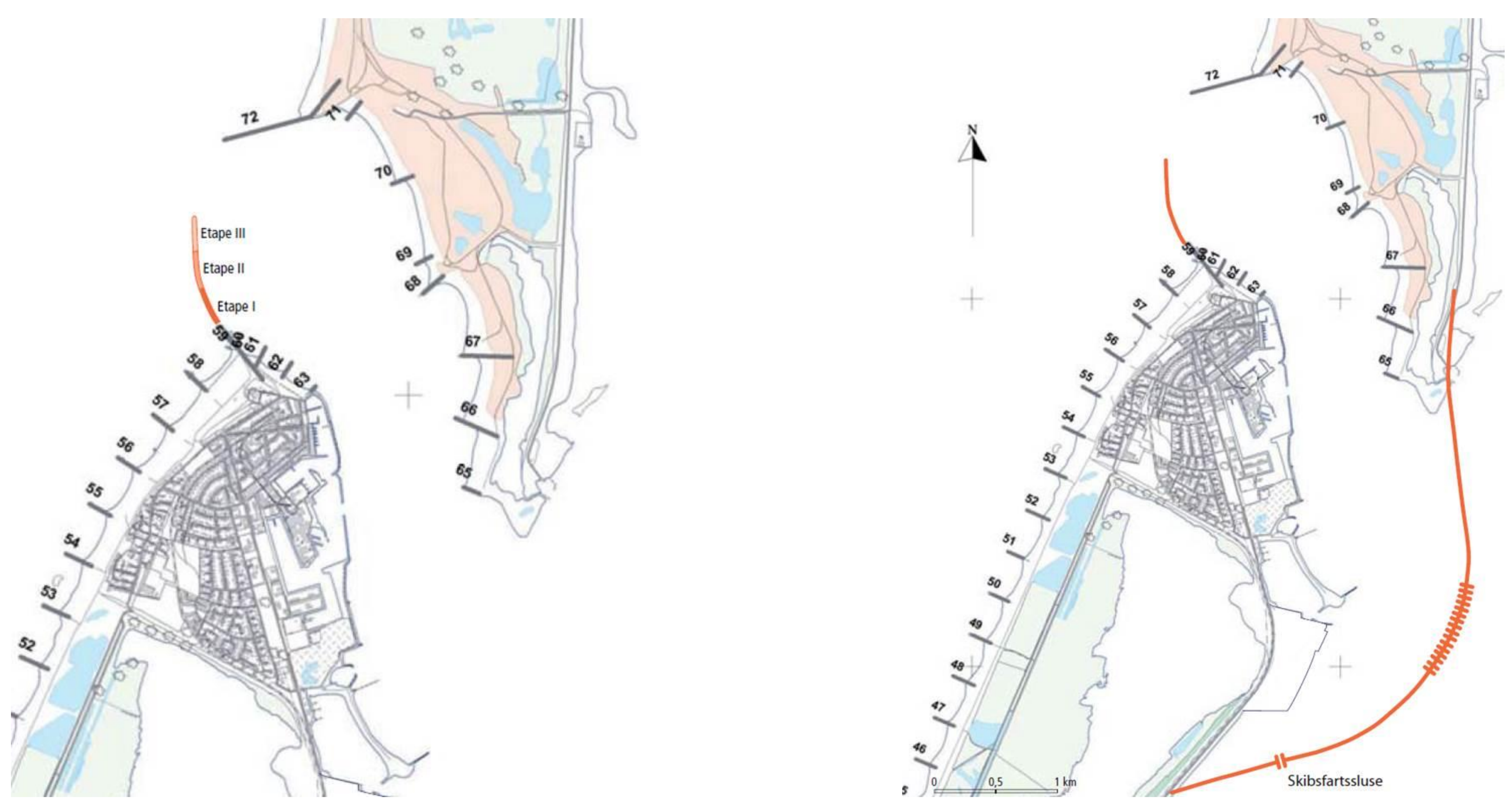

Figure 6. Technically preferred management option: extending a groin to at breakwater (left) and an alternative management option with a sluice.