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Use of GIS to analyse physical conditions related to Integrated Coastal Zone Management in Denmark

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Introduction

The present study is a tool for improved coastal zone management. The study was carried out by the Geological Survey of Denmark and Greenland for the National Forest and Nature Agency. The study is reported in Anthony (1998). The background for the study is an increasing focus on many unsuccesfull examples where the coastal zone has been managed on the basis of special interests. There are only few natural coastlines left in Denmark, even though the Danish coastline is relativily long (7.500 km).

The main objective of the project is to develop and test a method for implementation of coastal parameters related to physical settings into a GIS. One of the main benefits should be easy integration of coastal themes with administrative data.

Methods

Relevant coastal parameters have been identified. For the presented study area the chosen parameters are

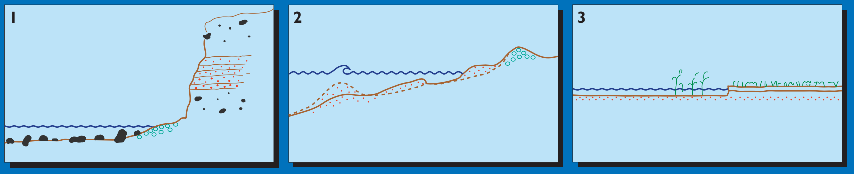
- Coast type
- Sediment type
- Degree of coastal protection
- Coastline displacement
- Impact of wave-induced energy

In order to make efficient GIS analysis, the geocoding are made by projecting the parameters into one specific coastline. All parameters are thereby represented as line data. This is, of course, only acceptable in areas where the marine impact in the landscape has a limited size.

To make comprehensive analysis of a specific area, these parameters are not sufficent, however they make a good and fast overall description, which easily can be combined with other GIS data.

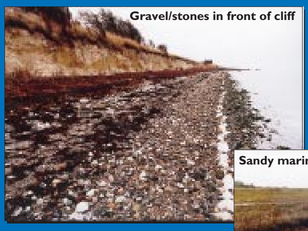
Sediment type, coastal protection and coastal type data are derived from a combination of field observations, oblique aerial photographs from low height and digital geocoded orthophotos. The latter data are used as on-the-screen background for the coast line. This is very useful when dividing the coastline into relevant classes for each of the chosen parameters. Each parameter is stored in a GIS-overlay. Because the geocoding expresses exactly the same coastline, analysis of the combinations of the parameters can easily be done. Moreover, a general description of the geological and dynamical settings are made.

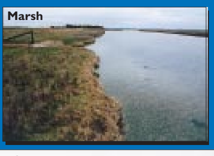
• Coast type



The coast is divided into four major classes: 1) cliff, 2) sandy marine foreland 3) marsh and 4) other/not defined. In cases where the coast obviously is a combination of two classes, e.g. a strip of marsh in front of a (fossil) cliff, the coast is classified accordingly, e.g. "class 3-1".

• Sediment type



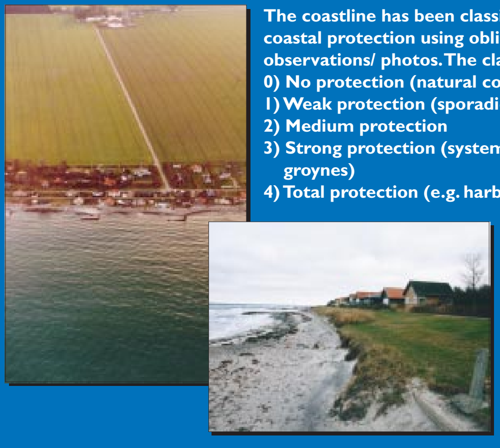


The sediment type along the coast in the study area varies from gravel/stone-dominated beaches to muddy coasts in embayments. At the beach in front of the cliffs, the sediment size distribution is much the same as the sediment distribution in the cliffs itself, except for the finest fractions, which rapidly washes away. However sorting across the beach as well as through the sediment appears, which very much complicates the sampling of representative samples. At the sandy marine foreland coasts, which are typical accumulation areas, the sand is much better sorted. Because of the relatively large study area, a simple and easily operational sediment classification was used. Four general groups were defined: 1) Sand and/or silt/clay, 2) predominantly sand, 3) sand and/or gravel/stones and 4) unknown/other. Field observations combined with oblique aerial photographs are used as basis for the interpretation.

• Degree of coastal protection

The coastline has been classified into five categories of coastal protection using oblique aerial photographs and field observations/ photos. The classes defined are:

0) No protection (natural coast)
1) Weak protection (sporadic protection)
2) Medium protection
3) Strong protection (systematic and massive protection with e.g. groynes)
4) Total protection (e.g. harbours)



Figures to the left shows examples of strong coastal protection

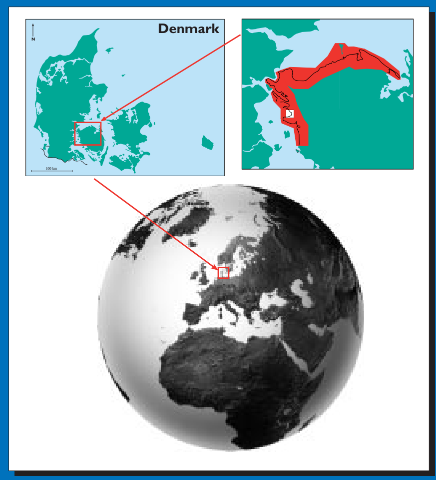
• Coastline displacement during the last approx. 125 years

The coastline from approx. year 1870 in the scale 1:20.000 has been digitized and compared to the most recent coastline of the region (approx. year 1995). By converting the coastline to land polygons and then subtracting the polygons from the two periods, the areas with net erosion or accumulation are easily visualised (see close-up example under "Examples of results").

• Impact of wave-induced energy

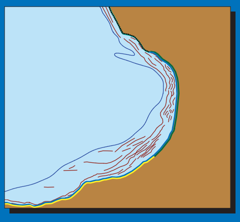
The fetch is calculated from hydrographic charts in intervals of 10 degrees. The wave energy from each relevant direction is then calculated using ACES software (CERC, 1992). Wind statistics are used to distribute the wave energy for each location accordingly with the wind distribution.

Location of field site



Examples of results

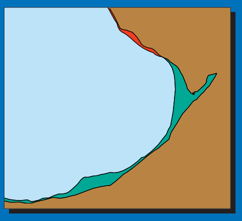
Close-up example of the GIS-data from a 4.6 km stretch of coastline in the western part of the investigation area (indicated on map above)



Coast type (seaward signature):
- sand-accumulating marine foreland
- cliffs

Sediment type (landward signature):
- sand
- gravel

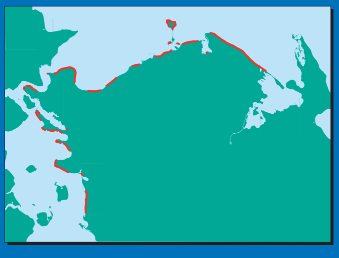
Coastline displacement during approx. 130 years
- net accumulation
- net erosion

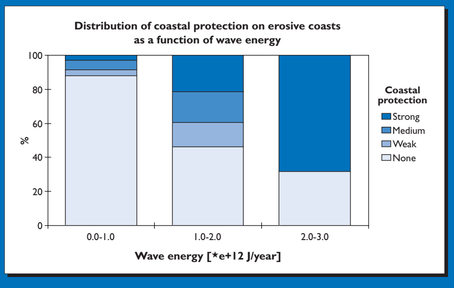


Wave-generated energy impact (seaward signature):
- 0.2-0.5*10^{12} J/year
- 0.5-1.0*10^{12} J/year

Coastal protection (landward signature):
- None

Orthophoto used as digitization background and as part of the basis of interpretation





The energy impact on all cliff-coasts has been grouped together in order to show if there is any tendency of correlation between the distribution of coastal protection and the amount of wave energy. Left figure shows the coastlines involved and the right figure shows the resulting diagram. At low wave energy most coasts are, understandably, non-protected, as the erosive potential is small. As the wave energy increases, the amount of coasts which is both weak, medium and strong protected is increased on expense of fraction of the non-protected coasts. At relatively high wave energy, the non-coastal protected coasts have diminished to approx. one third in this category. The other two thirds are all strongly protected. The intermediate categories of coastal protection are apparently non-efficient in this environment.

Status and further work

A wide range of coast-related physical parameters were mapped into a GIS, and the method has proved to be operational in the chosen study area. To test the methods value in practice, the next step could be a comprehensive coordination with administrative data. Moreover, it would be valuable to test the method in regions with other physical characteristics, where other parameters probably should be included.

References

Anthony, D. (1998): Integrated mapping of the coast to archive improved basis for management of the coastal zone. Phase 1 (in danish). Geological Survey of Denmark and Greenland.

CERC (1992): Automated Coastal Engineering System, Department of the Army Waterways Experiment Station.