DELOS – EVK3-CT2000-0041
Deliverable No 5 for WP1.1
LCS in DK

Based on the brief questionnaire

This document summarizes the information collected for DELOS WP1.1 “Inventory of engineering properties of LCS”.

DK Map


003
002
001
004
SKAGERRAK
KATTEGAT
ØSTERSØEN
SVERIGE
Skagen
Hirtshals
Hjørring
Frederikshavn
Brønderslev
Læsø
Hanstholm
Fjerritslev
Aalborg
Thisted
Aars
Nykøbing M
Hobro
Anholt
Lemvig
Skive
Struer
Viborg
Randers
Hadsten
Grenaa
Hobro
Hølstebro
Silkeborg
Ebeltoft
Herning
Ikast
Århus
Skanderborg
Ringkøbing
Skjern
Brande
Odder
Grindsted
Horsens
Samsø
Vejle
Fredericia
Varde
Vejen
Middelfart
Odense
Esbjerg
Fanø
Kolding
Ribe
Assens
Haderslev
Rømø
Aabenraa
Faaborg
Svendborg
Als
Tønder
Sønderborg
Ærø
Flensburg
DEUTSCHLAND
Langeland
Rødby
Nakskov
Maribo
Vordingborg
Stege
Møn
Nykøbing F
Rügen
(DEUTSCHLAND)
Göteborg
Varberg
Halmstad
Karlskrona
Helsingør
Helsingborg
Hundested
Hillerød
Nykøbing S
Frederikssund
København
Kalundborg
Holbæk
Roskilde
Malmö
Ystad
Sorø
Køge
Slagelse
Ringsted
Nyborg
Korsør
Skælskør
Næstved
Bornholm
Rønne
Neksø

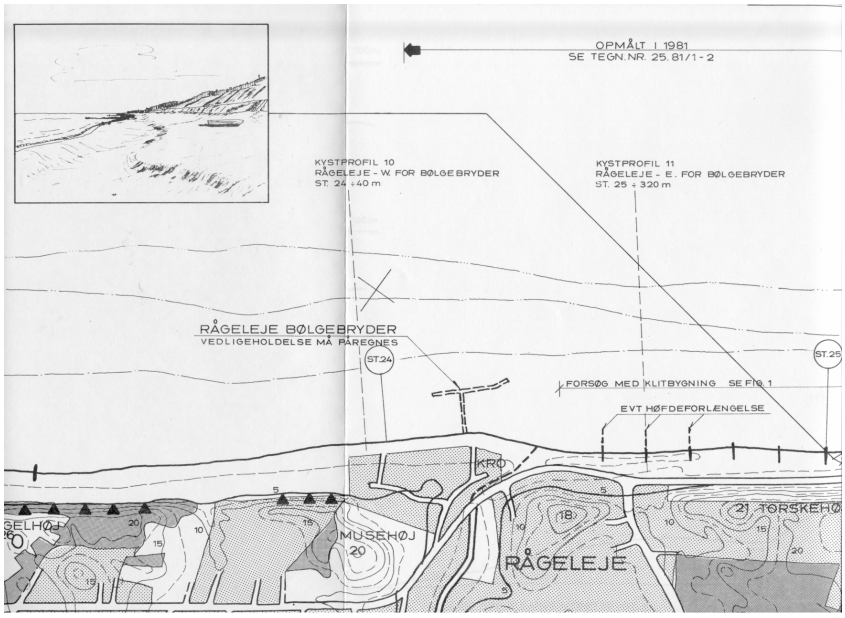
DHI_DK_001, LCS off Rågeleje harbour

Location

UTM-32 (easting, northing)=(6221746, 696617). The LCS is situated facing Rågeleje harbour (Municipality of Helsinge). Rågeleje is situated on the North coast of Sealand, Denmark – see map below (covering 12.5 km *12.5 km). Information presented below is based primarily on a report made for the local districts (among others Municipality of Helsinge) by DHI in 1984 and on the outline of the area shown in the lower figure (both Ref. /1/). Also a sociological description of the impact of the breakwater on the developments in the local community is available (from local historical archives, Ref. /2/).

Main reason for building the LCS

The Rågeleje structure was built in 1912, most likely to protect the coastline from extreme storm events. An extreme storm event took place in year 1902 heavily eroding the beach-meadows. The decision to built and the construction of the breakwater was actually done by local fisherman. It may also have been built for the purpose of sheltering the fisherman boats during storms. The breakwater was initially built as a emerged structure. Since 1928 the structure has not been maintained and has deteriorated slowly by the waves generated in Kattegat (the water body just north of Sealand, bounded to the east by Sweden and to the west by Jutland). As a consequence of this deterioration, the level of the crest is lower today than at construction so the breakwater has become a LCS. It has not been removed since its role even today is believed to be important in preserving the coastline. In fact it was recommended (by DHI in 1984) that the structure (as a well-functioning breakwater) should be maintained since the consequences of a total deterioration may most likely result in a general retreat of the coastline (Ref. /1/).



Impacts on bio-environment

Not known.

Socio-economic impact

Rågeleje is an old fishing village but now (actually since 1927) also a recreational area (summerhouses) which has become very popular during the last decades. After the construction of the breakwater erosion took place downdrift (East) of it. The initiation of erosion east and the advance of the coast west of the breakwater back in 1912 had a negative impact on the local fisherman community (Ref. /2). In Ref /2/ it can be read that the negative impact of the breakwater created a conflict in the community, dividing it into an eastern and western part (that is relative to the breakwater). As a defence against the coast erosion a number of groynes was built to the east (see figure above). Today, the presence of the breakwater is of no treat to the development of the area. The beach is stable, implying that there is a balance between the breakwater/groynes and the sediment transport generated by the breaking waves. This, on the other hand, indicates that the removal/deterioration of the breakwater may necessitate alternative schemes to protect the interest of the summerhouse owners.

System Layout (dimensioned sketch)

The beach profile is flat till about 150 meters from the coast where it becomes moderate (1:30). From approximately the 7 meter depth contour the slope becomes flat again (1:100). The depth 500 meters from the coast is app. 8 meters. See also map above.

Typical cross section (dimensioned sketch)

The structure is a rouble mound breakwater. The crest level of the structure is now at the daily mean water. The water depth is approximately 1 meter and the length of the structure is 140 meters and located 75 meters from the coast.

Indication of water level variations

Insignificant variations in water level from tide (18 cm from low to high spring tide). Storm surge return period 10 years: around 1.4 m above MSL.

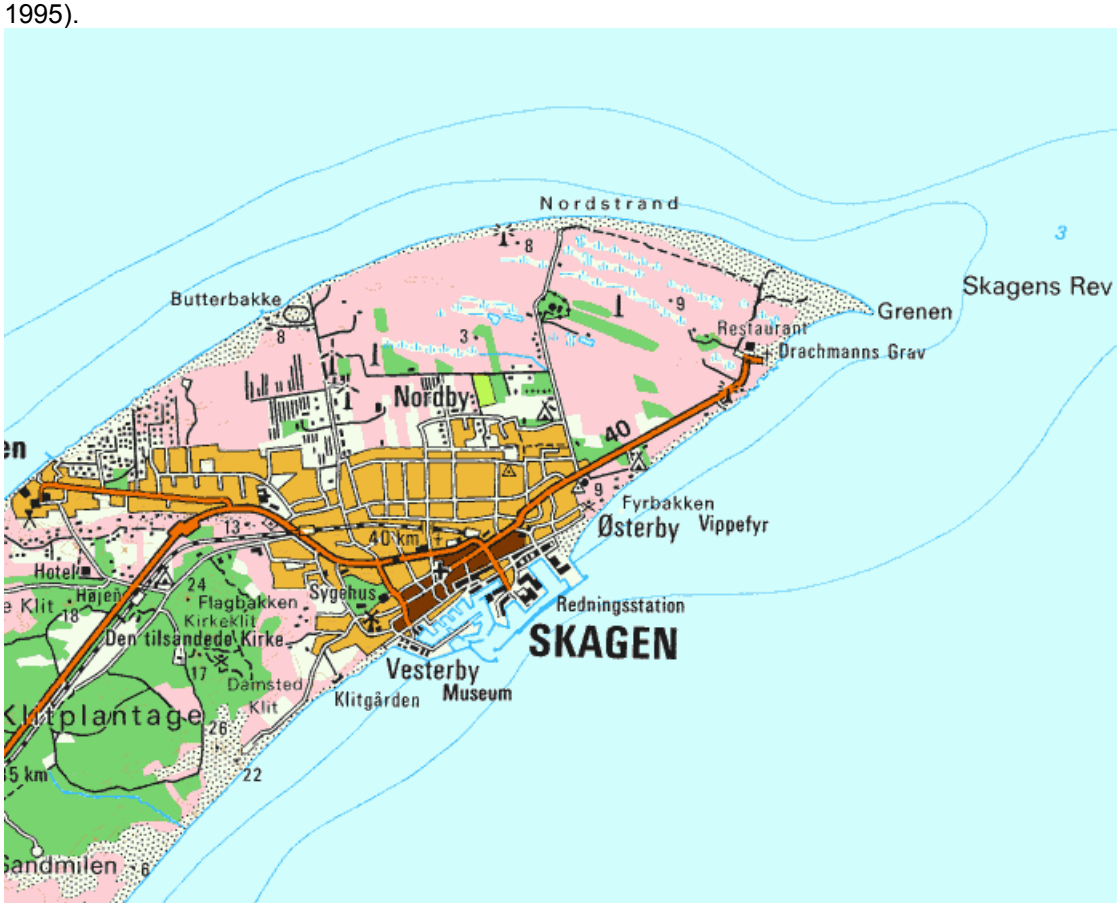
Existence of detailed information

The impact of the breakwater can be detected 700 meters east where a resistant hard point (Trillingerne, see map in upper figure) is located and protecting the coast from further erosion. The fact that the breakwater is very old allows its long-term influence on the coast to be studied and may for this reason be of interest for DELOS.

DHI_DK_002, Skagen, Kattegat coast of Jutland.

Location

UTM-32 – Skagen harbour - (easting, northing)=(594849, 6398591). At this location a system of breakwaters is located north and south of the harbour. They are built such that Skagen harbour is located approximately midway. Skagen harbour is located just south of the Skaw spit ('Grenen' on the map below) facing Kattegat. The map covers an area of app. 10.5*8.3 km2. Information on the breakwaters was provided by KDI (The Danish Coastal Authority, 1995).



Main reason for building the LCS

The breakwaters are build to protect the coast from the waves generated in Kattegat (the water body just north of Sealand, bounded to the east by Sweden and to the west by Jutland). Many different constructions have been made, rebuilt and even removed such that several construction schemes have been implemented over the years.

Impacts on bio-environment

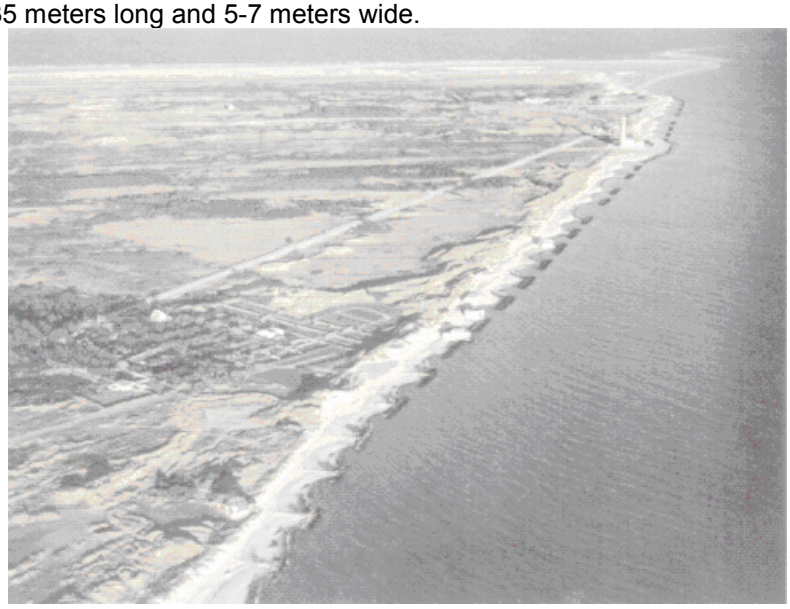
The area of interest is being nourished with sand between the coast to the breakwaters. There is hardly any bio-environment. The nourished sand contains little life and this sand is eroded continuously such that the sand supplied north of the harbour (except for that very close to the harbour) ends up around the Skaw spit.

Socio-economic impact

The area is a very popular tourist spot in Denmark and the area relies heavily – as it is – on tourism. Furthermore the harbour is very important with respect to landing, processing and distribution of pelagic fish (see www.ifm.dk).

System Layout (dimensioned sketch)

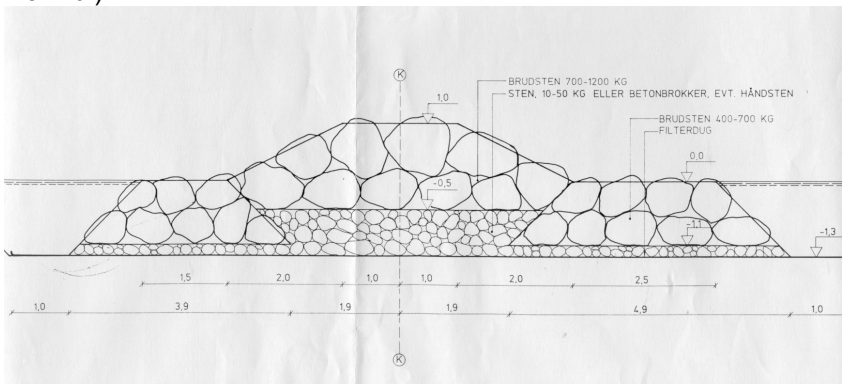
An aerial picture of the system of breakwaters found around Skagen harbour is shown below with the Skaw spit in the horizon.
Between the Grå Fyr lighthouse and the spit, 8 breakwaters have been constructed with gaps between them ranging from 20 to 30 meter (60 meters between number 5 and 6, though). They are 35 to 45 meters long and 10 meters wide. On the stretch from Grå Fyr to Skagen harbour 11 breakwaters were constructed, followed by 7 T-shaped breakwaters. The gaps between the breakwaters are 25 meters (except between number 3 and 4 and 5 and 6 with spacing of app. 80 meters). These are 42 meters long and 10 meters wide. On the southern side of Skagen harbour, south of Klitgården – see the map - 7 T-shaped breakwaters have been constructed. From here the T-shaped structures are followed by 5 breakwaters. The distance between these individual breakwaters (the gap) is 25-30 meters. On average they are app. 30-35 meters long and 5-7 meters wide.



They all have circular round head and aligned parallel to the coast. The system of breakwaters found along the coastline is located sufficiently close to the beach so that tombolo formations are generated. They are without exception connected to the coast, which properly is due to the nourishment. The water depth on the offshore facing side is approximately 1 meter.

Typical cross section (dimensioned sketch)

They are all rouble mound breakwaters. A sketch of typical cross-section is shown in the figure below (from Kystdirektoratet). The level of the crest is seen to be 1 meter above DNN (Dansk Normal Nul).



Indication of water level variations

The difference between the water level at mean low and mean high tide is 0.3 meter. Storm surge return period 10 years: around 1.24 m above MSL (Reference: Skagen 1981, Kystinspektoratet).

DHI_DK_003, Lønstrup, Westcoast of Jutland.

Location

UTM-32 – (easting, northing)=(547655, 6370268). The map below shows the location of Lønstrup. Both north and south of this site a system of breakwaters is located (see aerial foto below – from Ref. /1/). Information on the breakwaters are obtained from Ref. /1/.

Main reason for building the LCS

The breakwaters were built to protect the small village Lønstrup located near the sea and the adjacent beaches from the ongoing coastal erosion caused by the North Sea waves. The coast at Lønstrup will if unprotected erode 1.5 m/year in fact during a storm back in 1981 some places up to 15 m which initiated the construction of a protection scheme in 1982/1983.

Impacts on bio-environment

The area of interest is being nourished with 20.000-30.000 m3/y sand between the coast and the breakwaters. There is hardly any bio-environment.

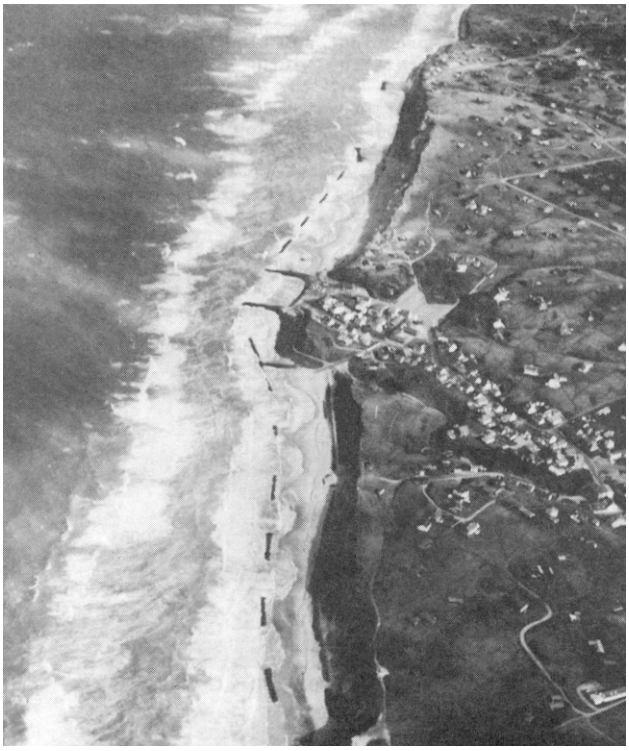
Socio-economic impact

The area is a popular tourist and nature spot in Denmark and many summerhouses are located here.

System Layout (dimensioned sketch)

An aerial photo of the system of breakwaters at Lønstrup is shown below. The system is 1100 m long.
Each breakwater is built on approximately 1 meters water depth. They are 45 meters long and separated by 45 meters as well.

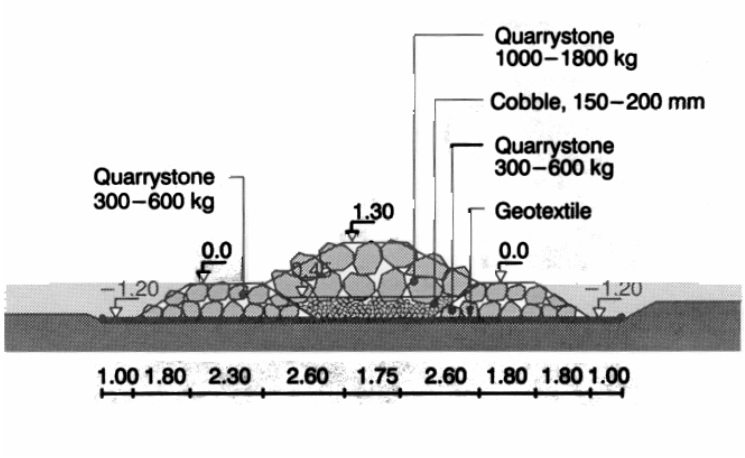
Ref /1/: Laustrup, C., Madsen, H. T. “Design of Breakwaters and Beach Nourishment”. 24’th Internal Conference on Coastal Engineering, 1994, Kobe, Japan, ASCE.



All breakwaters have circular round heads and are aligned parallel to the coast. The system of breakwaters found along the coastline is located sufficiently close to the beach so that tombolo formations are generated (see aerial photo).

Typical cross section (dimensioned sketch)

All breakwaters are rouble mound breakwaters. A sketch of typical cross-section is shown in the figure below (from Ref. /1/). The level of the crest is seen to be 1.3 meter above MSL.



Indication of water level variations

The tidal range is 0.3 meter.

DHI_DK_004, Liseleje, North coast of Zealand.

Location

UTM-32 – (easting, northing)=(684549, 6211899). A system of LCS's is situated near Liseleje on the North coast of Zealand, Denmark – see map below. The system contains new as well as old breakwaters.

Main reason for building the LCS

A new system of breakwaters was constructed in 1997. The old system contained many small dissimilar breakwaters. The breakwaters have been constructed with the purpose of preventing coastal and cliff erosion along a coastline that is classified as having regional importance. This is partly due to the unique nature of the area and partly due to recreational interests and tourism.

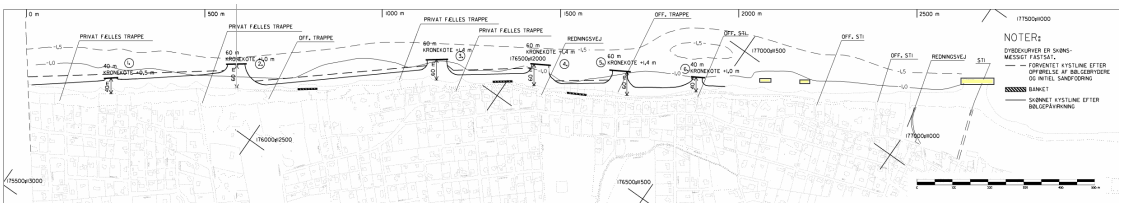
Socio-economic impact

The area is a popular tourist and nature spot in Denmark and many summerhouses are located here.

System Layout (dimensioned sketch)

A sketch of the system of new breakwaters along the coast of Liseleje is shown below. In total 6 new breakwaters were constructed. Only 3 of the old breakwaters were preserved. The new breakwaters are located 60 meters offshore from the original coastline, except for the two

outermost, which are located 40 meters from the coastline. The breakwaters are 60 meters long, except for the two outermost which are 40 meters long.



The levels above MSL of the crests vary. Respectively, from west to east the crest are located 0.5 m, 1.0 m, 1.4 m, 1.4 m, and 1.0 m above MSL. The water depth at the shore-face of the structures is approximately 1.0-1.5 meters. The spacing varies as well. From west to east: 300 m, 445 m, 230 m, 270 m, and 160 m.

Most of the breakwaters from the old system of breakwaters were removed in 1997 and the material was reused in the new system of breakwaters, however, 3 of them were preserved. One of the preserved breakwaters was the well-known Liseleje breakwater (located in the figure above app. 700 meter east of the eastern part of the new system). The two other of the old breakwaters are located between the Liseleje breakwater and the eastern most part of the new system (app. 150 meter from the eastern most breakwater of the new system).

The system of breakwaters found along the coastline is located sufficiently close to the beach so that tombolo formations are generated (see aerial photo).

Impacts on bio-environment

The area of interest is being nourished, however, existing breakwaters from the old system of breakwaters may contain a well-established bio-environment. If so, this may affect the bio-environment developing on the new breakwaters (depending on the distance between them).

Typical cross section (dimensioned sketch)

N/A

Indication of water level variations

Insignificant variations in water level from tide (18 cm from low to high spring tide). Storm surge return period 10 years: around 1.45 m above MSL. The significant wave height return-period 10 years: 3.4 meter.

Existence of detailed information

On the entire Hundested-Gilleleje stretch (see map), the coast is dominated by waves from west and northwest. These waves cause a netto-transport of material towards east at app. 10.000-30.000 m3/yr.