

DELOS – EVK3-CT2000-0041
Deliverable No 5 for WP1.1
LCS Inventory summary

- Second draft, December 17th 2001 -

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

Available documents within WP 1.1	2
LCS in Denmark.....	3
LCS in the Netherlands.....	5
LCS in Italy, the part provided by UR3/MOD	6
LCS in Italy, the part provided by UB.....	8
LCS in Greece	10
LCS in Spain	12
LCS in UK	14
LCS in France	16
LCS in USA.....	17
LCS in Japan.....	19

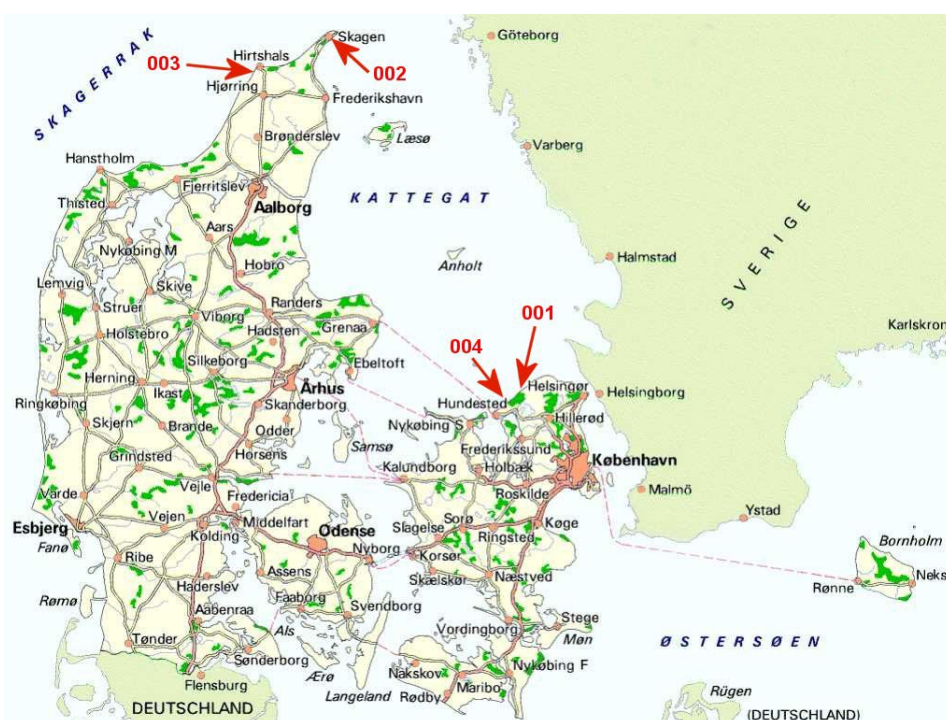
In the subsequent tables maximum, minimum and average/typical information is specified for the LCS's in each country. Parameters are specified only for the detached LCS part of the scheme.

Available documents within WP 1.1

The following documents can be downloaded from the Internet www.delos.dk and can also be reached from the project homepage on the Internet www.delos.unibo.it.

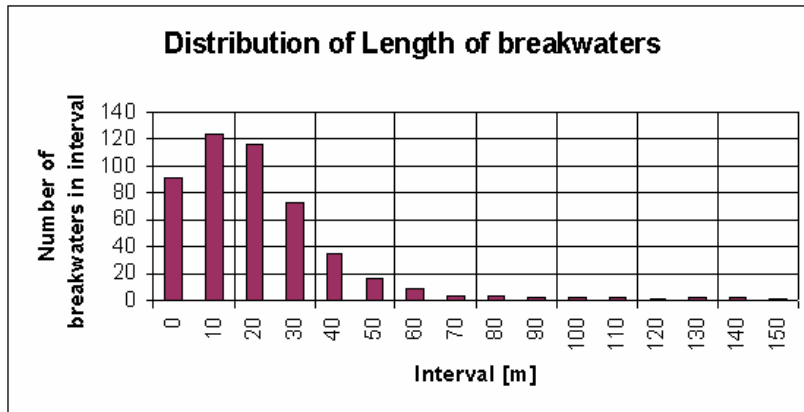
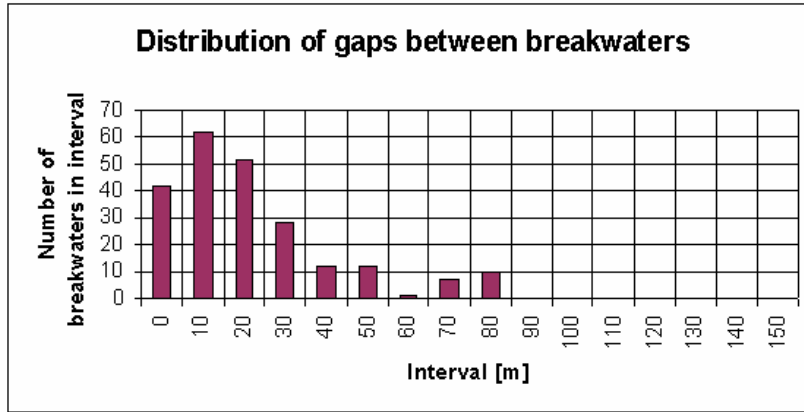
- **Inventory summary** (this document)
- **Inventory Statistics.** The document summarizes statistics on LCS's geometry mainly within EU. The Excel-database used for the calculation is also available.
- **Proceedings** from meeting in Aalborg 1-2 June 2001 in WP1.1 (especially the ones by UB, UR3/MOD and AUTH summarize statistics).
- **DK** (DHI): 4 brief questionnaires
- **NL** (INF): 6 brief questionnaires
- **IT** (UR3/MOD): 18 brief questionnaires
- **IT** (UR3/MOD): 3 detailed questionnaires
- **IT** (UB): 56 brief questionnaires
- **IT** (UB): 1 detailed questionnaire of Lido di Dante
- **GR** (AUTH): 4 brief questionnaires
- **GR** (AUTH): 2 detailed questionnaires
- **ES** (UPC): 28 brief questionnaires
- **UK** (UoS): 34 brief questionnaires
- **French coast** (CSIC, CREOCEAN): Inventory of the existing structures on the French coast
- **Non EU** (UCA): Inventory of LCS in USA and Japan.

LCS in Denmark



Information collected by partner	DHI
No. of investigated sites	4 sites for the brief questionnaire, Simple statistics for 496 breakwaters.
Purpose	Beach protection to protect land or buildings.
Construction types	Mainly simple groynes and detached breakwaters used for beach protection.
Length of segments [m]	Based on subsequent information: 5 (Minimum) 29 (Typical) 169 (Maximum)
Gap [m]	Based on subsequent information: 4.2 (Minimum) 26.5 (Typical) 88.7 (Maximum)
Distance to shoreline [m]	Based on brief questionnaire: 25 (Minimum) 50 (Typical) 75 (Maximum)
Freeboard [m]	Based on brief questionnaire: 0.0 (Minimum) +1.0 (Typical) +1.3 (Maximum)
Crest width [m]	Based on brief questionnaire: 2.0 (Minimum) 2.5 (Typical) 3.0 (Maximum)
Water depth [m]	Based on brief questionnaire: 1.0 (Minimum) 1.1 (Typical) 1.2 (Maximum)
Water level variations [m]	0.4 (Typical) 2.0 (Maximum)

Along the Danish coasts about 500 breakwaters exist. These breakwaters are not designed as Low Crested Structures. However in storms the breakwaters are overtopped due to the fact that the crest freeboard is about +1 to +2 meters. The construction material is mainly rubble mound. In addition to the brief questionnaire a simple statistics for 496 breakwaters were made. The gap and the length of the structures were calculated from existing UTM-coordinates (the data were provided by KDI). All gaps less than 4m or larger than 100m were ignored.

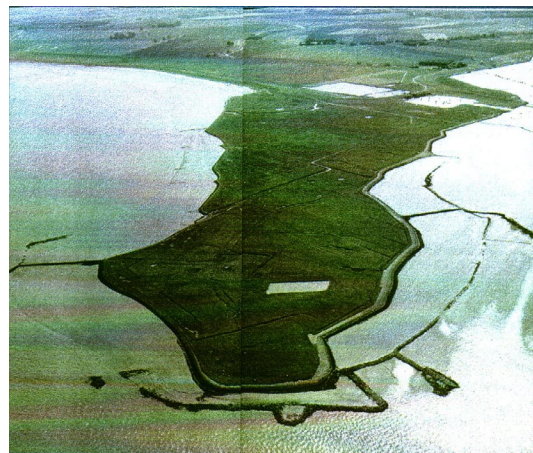


LCS in the Netherlands

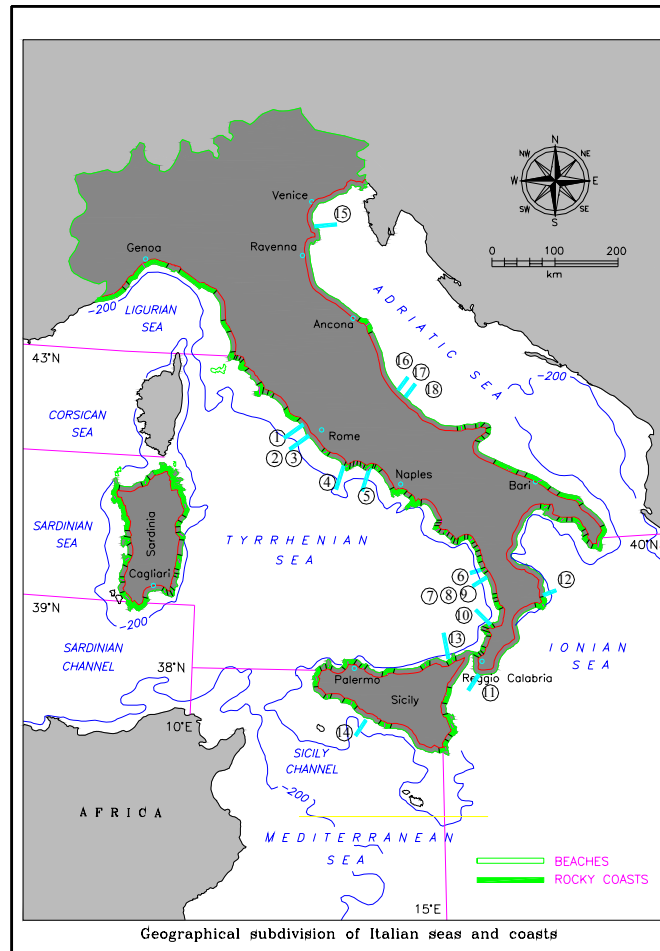


Information collected by partner	INF
No. of investigated sites	6 sites for the brief questionnaire.
Purpose	Various
Construction types	Various
Length of segments [m]	-
Gap [m]	-
Distance to shoreline [m]	-
Freeboard [m]	-
Crest width [m]	-
Water depth [m]	-
Water level variations [m]	1.5 (Minimum) 1.6 (Typical) 2.0 (Maximum)

The Low Crested Structures in the Netherlands are rather atypical; only one structure is protecting a beach. The following pictures are from Punt van Reide (structure no. 001), where the structures were built for ecological reasons.

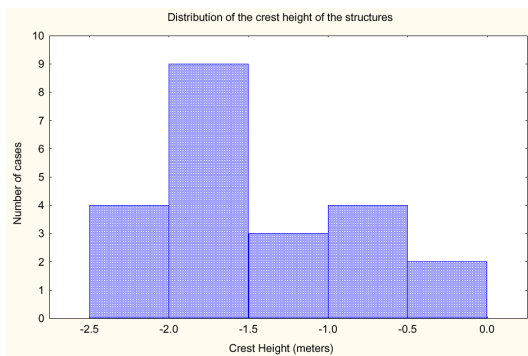
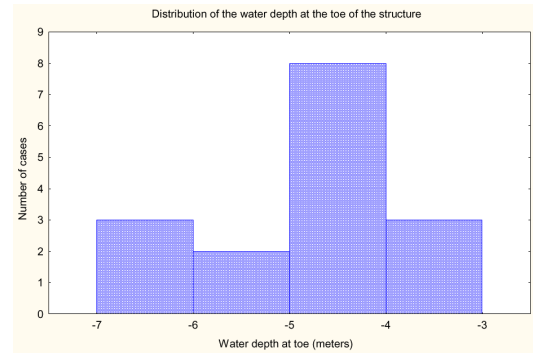
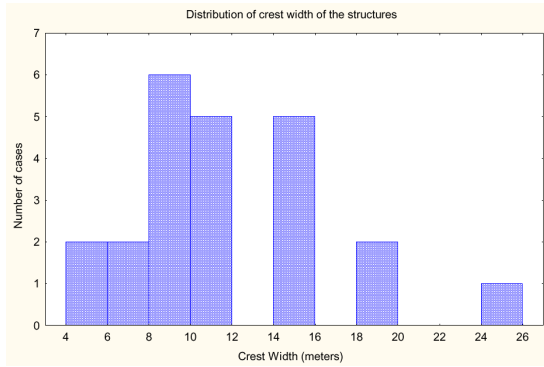


LCS in Italy, the part provided by UR3/MOD



Information collected by partner	UR3/MOD
No. of investigated sites	18 sites for the brief questionnaire.
Purpose	Beach protection to protect land or buildings.
Construction types	Mainly detached breakwaters used for beach protection.
Length of segments [m]	30 (Minimum) - (Typical) 3000 (Maximum) *
Gap [m]	-
Distance to shoreline [m]	55 (Minimum) ~150 (Typical) 300 (Maximum) *
Freeboard [m]	-1.75 (Minimum) -1.1 (Typical) 0.0 (Maximum) *
Crest width [m]	6 (Minimum) 13 (Typical) 20 (Maximum) *
Water depth [m]	2.5 (Minimum) 4.3 (Typical) 6.5 (Maximum) *
Water level variations [m]	0.4 (Minimum) 0.5 (Typical) 1.0 (Maximum) *

*) More information is available in the document presented at the meeting in Aalborg 1-2 June 2001 "Inventory of Italian LCS". Some statistics is also presented in this proceeding, including the following figures.



LCS in Italy, the part provided by UB

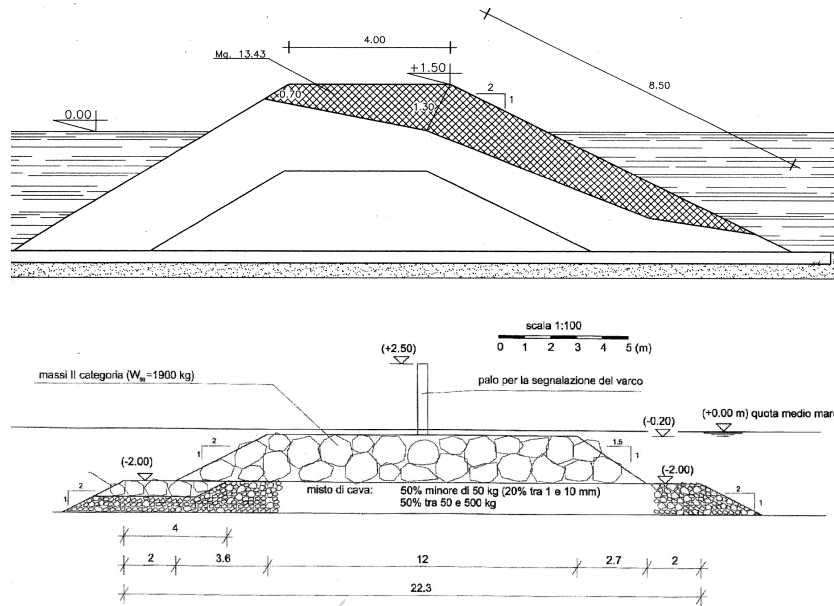
UB has provided information regarding LCS's in the region no. 2, 3, 6, 11 and 12 (see subsequent map). The exact geographical location of the sites is shown in the document with the brief questionnaires.



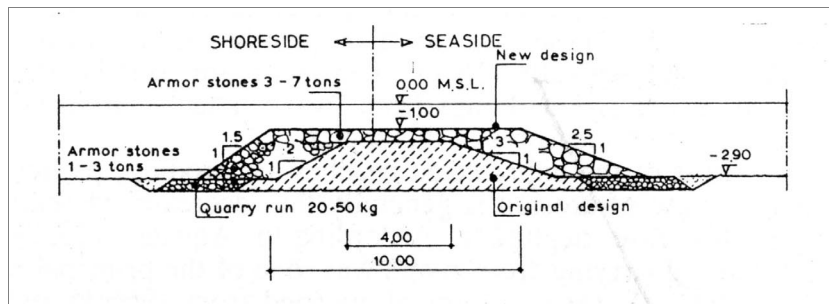
Information collected by partner	UB
No. of investigated sites	56 sites for the brief questionnaire.
Purpose	Beach protection to protect land or buildings.
Construction types	Mainly detached breakwaters used for beach protection.
Length of segments [m]	20 (Minimum) 100 (Typical) 1500 (Maximum)
Gap [m]	~0 (Minimum) 30 (Typical) 102 (Maximum)
Distance to shoreline [m]	0 (Minimum) 100-150 (Typical) 260 (Maximum)
Freeboard [m]	-1.0 (Minimum) -1.0 or +1.5 (Typical) +2.0 (Maximum)
Crest width [m]	2 (Minimum) 4 or 10 (Typical) 12 (Maximum)
Water depth [m]	1.6 (Minimum) 3.0 (Typical) 5.0 (Maximum)
Water level variations [m]	0 (Minimum) 0.3 (Typical) 0.8 (Maximum)

A completed detailed questionnaire exists for Lido di Dante (Ravenna).

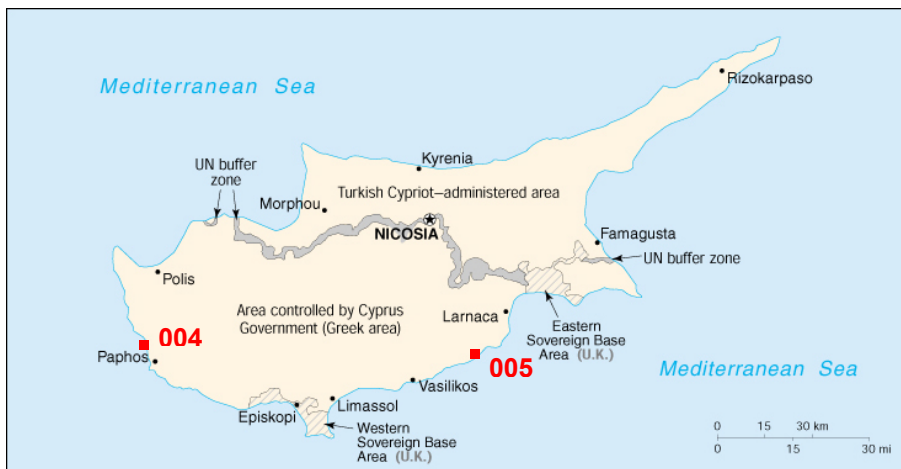
More information is available in the document presented at the meeting in Aalborg 1-2 June 2001 "Inventory of LCS by UB: Preliminary considerations". The following figures are from this proceeding. The following figure shows a typical cross-shore section of emerged and submerged breakwater along Emilia Romagna coast (The North Adriatic coast).



Typical cross-shore section in the Marche region:



LCS in Greece



Information collected by partner	AUTH
No. of investigated sites	4 sites for the brief questionnaire, 2 of them on Cyprus.
Purpose	Beach protection to protect land or buildings.
Construction types	Detached breakwaters used for beach protection.
Length of segments [m]	70 (Minimum) 100 (Typical) 140 (Maximum)
Gap [m]	20 (Minimum) 30 (Typical) 40 (Maximum)
Distance to shoreline [m]	63 (Minimum) 100 (Typical) 140 (Maximum)
Freeboard [m]	0.0 (Minimum) +0.6 (Typical) +1.2 (Maximum)
Crest width [m]	3.0 (Minimum) 5 (Typical) 7.5 (Maximum)
Water depth [m]	2 (Minimum) 3.5 (Typical) 4.5 (Maximum)
Water level variations [m]	-

2 detailed questionnaires have been completed. No. 003 (for location see map above) Lakopetra, Ahaia (the picture below to the left shows the beach a few month after the project's completion) and no. 004 Paphos on Cyprus (the picture below to the right shows a view of the beach and the breakwater).



No. 003 consists of three successive detached breakwaters parallel to the shoreline. The scheme was constructed in 1992 in order to protect and stabilize a 300 m sandy beach section that lies in front of a hotel. The beach was particularly vulnerable to wave attack which posed hazards to the swimmers.

No 004 is a detached breakwater parallel to the shoreline. The beach that extends in front of a hotel is rocky hence it was inaccessible to swimmers. To overcome this deficiency a sufficient amount of rocky mass was excavated and removed and an artificial beach pocket was created applying sand nourishment. Considering that the coastline in the area is subject to significant wave action, the breakwater was constructed in order to maintain and enhance the pocket.

LCS in Spain



Information collected by partner	UPC
No. of investigated sites	28 sites. 21 at the Spanish Mediterranean Coast, 7 at the Canary Islands.
Purpose	Beach protection to protect land or buildings.
Construction types	Mainly detached breakwaters used for beach protection.
Length of segments [m]	25 (Minimum) 140 (Typical) 412 (Maximum)
Gap [m]	-
Distance to shoreline [m]	25 (Minimum) 130 (Typical) 270 (Maximum)
Freeboard [m]	-3.6 (Minimum) +0.5 (Typical) +2.5 (Maximum)
Crest width [m]	4 (Minimum) 5 or 15 (Typical) 20 (Maximum)
Water depth [m]	1 (Minimum) 5 (Typical) 9 (Maximum)
Water level variations [m]	0.25 (Minimum) 0.5 or 2.7 (Typical) 3.0 (Maximum)

The structures at the Spanish Mediterranean Coast and the structures at the Canary Islands are quite different, e.g.

- A) The tidal range on the Canary Islands is large (2.5-3m). On the Spanish Mediterranean Coast it is below 1m.
- B) The structures on the Canary Islands are built in large water depth (5-9m). On Spanish Mediterranean Coast the water depth is typical below 5m.
- C) The slope of the beach is typical more steep on the Canary Islands.

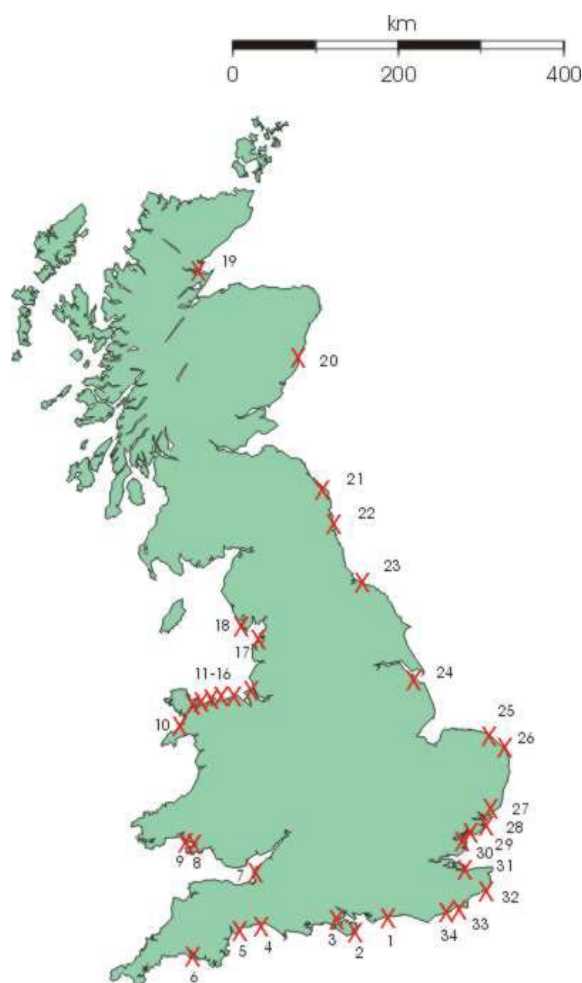
Playa de Cubelles (Beach of Cubelles) location number 001, Barcelona, is shown on the picture below.



Playa de Baja Mar (Baja Mar Beach) location number 025, La Palma, Canary Islands, is shown on the picture below.



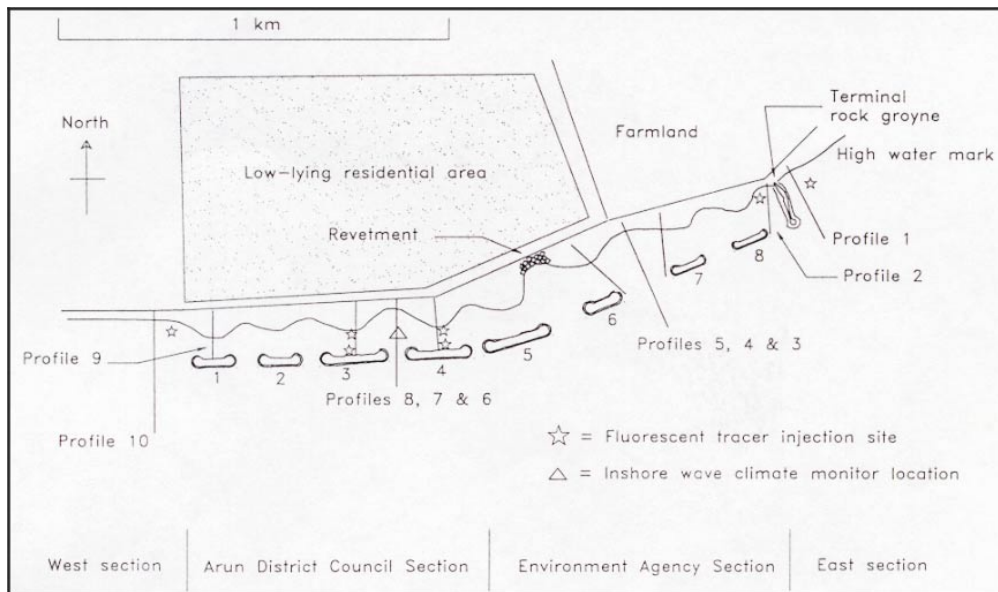
LCS in UK



Information collected by partner	UoS
No. of investigated sites	34 sites for the brief questionnaire.
Purpose	Beach protection to protect land or buildings.
Construction types	Mainly simple groynes and detached breakwaters used for beach protection.
Length of segments [m]	75 (Minimum) 500 (Maximum)
Gap [m]	-
Distance to shoreline [m]	0 (Minimum) 200 (Maximum)
Freeboard [m]	0.0 (Minimum) +7.3 (Maximum)
Crest width [m]	4.0 (Minimum) 6.0 (Maximum)
Water depth [m]	0.0 (Minimum) 6.0 (Maximum)
Water level variations [m]	2.0 (Minimum) 11.0 (Maximum)

In UK a broad range of structures have been investigated and included in the inventory. This includes detached breakwaters, a lot of schemes with fishtail groynes, L-shaped groynes, and a scheme with cliff stabilization structures. Therefore the detail of the structural geometry in the brief questionnaire is generally limited except for the Elmer scheme.

The Elmer scheme consists of 8 shore parallel structures and a terminal rock armour groyne. Each structure is approximately 6m high and 4m wide. They are situated at an average of 130m from the sea wall. The location is ideal for further investigation as there is already a great deal of detailed information about the scheme, the structures, the sedimentology, the hydrodynamics, and the beach morphology.



LCS in France

The document with the title "Report 101716" by CSIC/CREOCEAN describes the existing structures along the French coast. The document describes the following subjects:

- 1) Submerged groynes
- 2) Beach threshold
- 3) Structures into geotextile
- 4) Artificial reefs
- 5) Artificial algae

LCS in USA

The document "UCAinventory, INVENTORY FOR USA LCS" provided by UCA contain information about U.S. breakwater projects. The document is mostly based on structures in the report:

"Engineering Design Guidance for Detached Breakwaters as Shoreline Stabilization Structures" by Monica A Chasten, Julie D Rosati, John W McCormick. Coastal Engineering Research Center. U.S. Army Corps of Engineers. Waterways Experiment Station. CERC-93-19. December 1993.

The breakwater projects in this report is included in the inventory and summarized in the subsequent table on the next page.

Information regarding two sites comes from K.J. McIntosh et al. (1988). 21st ICCE. Pp 2840-2854.

Table 1
Summary of U.S. Breakwater Projects

Coast	Project	Location	Date of Construction	Number of Segments	Project Length	Segment Length	Gap Length	Distance Offshore	Water Depth	Fill Placed	Beach Response*	Constructed by	Maintained by
Atlantic	Winthrop Beach (low tide)	Massachusetts	1935	5	625m	91m	30m	Unknown	3.0m (mlw)	No	1	State of Mass.	
Atlantic	Winthrop Beach (high tide)	Massachusetts	1935	1		100	30	305	3.0 (mlw)	No	3	State of Mass.	
Atlantic (Potomac River)	Colonial Beach (Central Beach)	Virginia	1982	4	427	61	46	64	1.2	Yes	2	USACE	
Atlantic (Potomac River)	Colonial Beach (Castlewood Park)	Virginia	1982	3	335	61.93	26.40	46	1.2	Yes	1	USACE	
Chesapeake Bay	Elm's Beach (wetland)	Maryland	1985	3	335	47	53	44	0.6-0.9	Yes	1	State of Maryland	
Chesapeake Bay	Elk Neck State Park (wetland)	Maryland	1989	4	107	15	15		0.6-0.9	No	2-4	USACE	USACE
Chesapeake Bay	Terrapin Beach (wetland)	Maryland	1989	4		23	15.31,23	38.1	0.6-0.9	Yes	5	USACE	USACE
Chesapeake Bay	Eastern Neck (wetland)	Maryland	1992-1993	26	1676	31	23		0.3-0.6	Yes		US Fish and Wildlife Service, USACE	US Fish and Wildlife Service
Chesapeake Bay	Bay Ridge	Maryland	1990-1991	11	686	31	31	42.7		Yes	4	Private	Private
Gulf of Mexico	Redington Shores	Florida	1985-1986	1	100	100	0	104		Yes	1	USACE	USACE
Gulf of Mexico	Holly Beach	Louisiana	1985	6	555	46.51,50	93.89	78.61	2.5	No	4	State of Louisiana	State of Louisiana
Gulf of Mexico	Holly Beach	Louisiana	1991-1993	76		46.53	91.84	122,183	1.4,1.6	Yes	3	State of Louisiana	State of Louisiana
Gulf of Mexico	Grand Isle	Louisiana		4	84	70	21	107	2	No	3	City of Grand Isle	City of Grand Isle
Lake Erie	Lakeview Park	Ohio	1977	3	403	76	49	152	3.7	Yes	4	USACE	City of Lorain
Lake Erie	Presque Isle	Pennsylvania	1978	3	440	38	61.91	60	0.9-1.2	Yes	2	USACE	USACE
Lake Erie	Presque Isle	Pennsylvania	1989-1992	55	8300	46	107	76-107	1.5-2.4 (lwd)	Yes	3-4	USACE	USACE
Lake Erie	Lakeshore Park	Ohio	1982	3	244	38	61	120	2.1	Yes	5	USACE	City of Ashtabula
Lake Erie	East Harbor	Ohio	1983	4	550	46	90,105,120	170	2.3	No	5	State of Ohio	State of Ohio
Lake Erie	Maurnee Bay (headland)	Ohio	1990	5	823	61	76		1.3	Yes	1	USACE	State of Ohio
Lake Erie	Sims Park (headland)	Ohio	1992	3	975	38	49		2.5	Yes	1	USACE	City of Euclid
Pacific	Venice	California	1905	1	180	180	0	370		No	5	Private	
Pacific	Haleiwa Beach	Hawaii	1965	1	49	49	0	90	2.1 (msl)	Yes	3	USACE/State of HI	USACE
Pacific	Sand Island	Hawaii	1991	3	110	21	23			Yes		USACE	USACE

* Beach response is coded as follows: 1-permanent tombolos, 2-periodic tombolos, 3-well developed salients, 4-subdued salients, 5-no sinuosity

LCS in Japan

The document "UCAinventory, Japan Inventory" provided by UCA contain information about detached breakwater projects in Japan. The document is mostly based on structures and statistics presented in:

T. Uda. Statistical analysis of detached breakwaters in Japan (1988). 21st ICCE. Pp. 2028-2042.

Information regarding one site comes from O. Toyoshima (1982). 18th ICCE. Pp. 1873-1892.

The following four figures are examples taken from T. Uda's statistics.

