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DELOS WP 1.1 Inventory on LCS, detailed description

According to DELOS WP 1.1 an inventory for existing low crested structures (LCS) must be established. As low crested structure we mean structures designed to be submerged or regularly overtopped by waves. The detailed inventory (described below) concerns shore parallel structures including shore-attached structures, which are perpendicular to shoreline if part of the scheme. This inventory will be established through a digital questionnaire located at www.delos.dk

The inventory is established in the following way:

- A brief description is given for each LCS (another document). This description should be given for all kinds of LCS.
- Some structures/locations are selected for further investigations
- A more detailed description is given for the selected structures/locations (this document). This part shall focus on shore parallel structures including shore-attached structures, which are perpendicular to shoreline if part of the scheme.

Both the brief and the detailed descriptions will be presented on www.delos.dk

For each structure the following information should be given.

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How to use this document

In this document, you can give a detailed description of a specific LCS. The description must be completed within this digital document. Just type the text in the tables, insert relevant pictures, drawings, sketches etc. and save the document. Only relevant information should be included in the document; existing non-used tables, sketches etc. present in this document must be deleted. The existing figures etc. are meant to be guidelines that can be changed for a specific environment. But please keep the structure of the document intact.

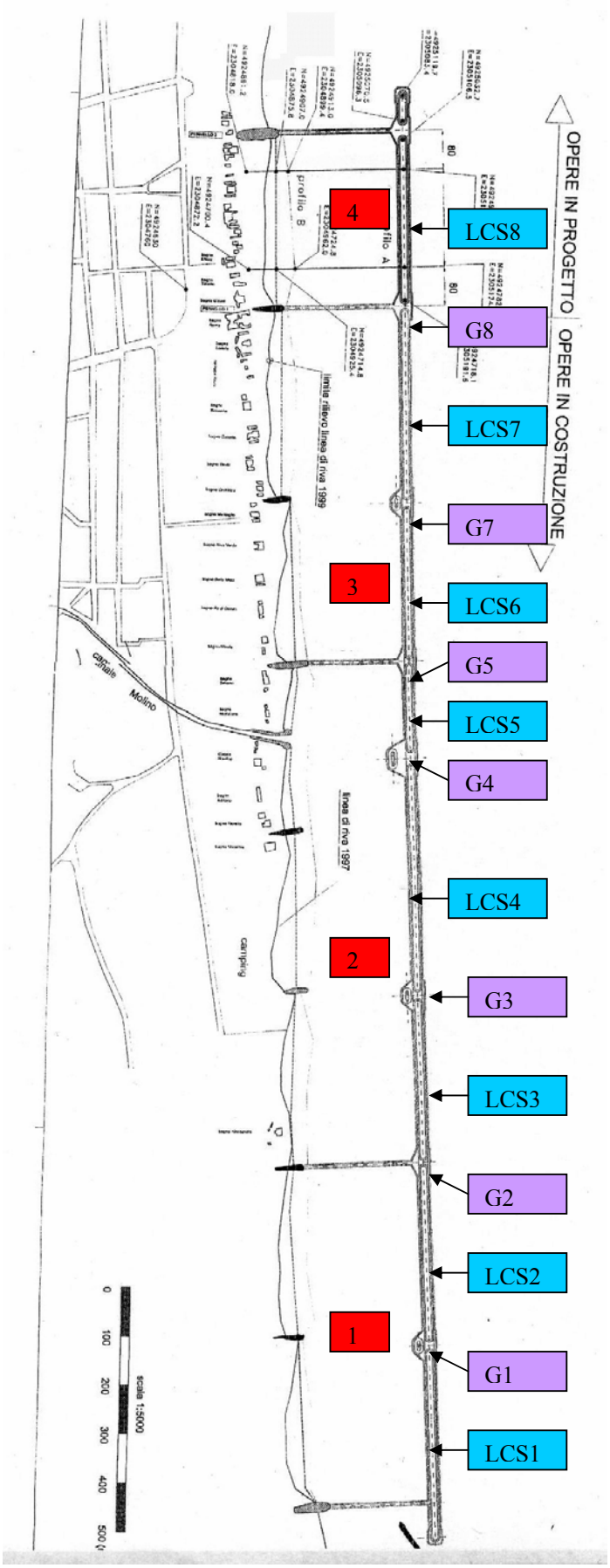
When completed, please attach the document to an email and send it to i5mkr@civil.auc.dk.

The filenames for the documents must include the participant code, the Country Code (as used on the Internet for Country Code Domains) and a Location-number between 001 and 999. It is very important that the same Location-number is used as for the brief description. The letters "det" must also be included to indicate that the detailed version of the questionnaire is used. The filenames for UB collecting information from East Italy (see special Country Code below) will therefore be "UB_EIT_det_001.doc" till "UB_EIT_det_999.doc". Each participant must provide a map of the country showing all the locations of the sites of interest, the Location-numbers must appear on this map.

Inputs come from:
UPC: Spain (Country Code ES)
DHI: Denmark (Country Code DK)
MOD & UR3: West Italy (Country Code WIT)
UB: East Italy (Country Code EIT)
AUTH: Greece (Country Code GR)
INF: Holland (Country Code NL)
UCA: non European LCS by literature study (Country Code nonEU)
UoS: U.K. (Country Code UK)

A: Formalities

Participant code and who to contact.	UB_EIT EMANUELA CLEMENTI
E-mail	emanuela.clementi@mail.ing.unibo.it
This date (today, mm:dd:yyyy) and revision number (A..Z).	02:15:2003
Location of LCS.	PUNTA MARINA (RAVENNA)
Start date, length and/or end of works. Have there been any later changes? If so, when?	I DESIGN: 1999-2001 II DESIGN: 2001 III DESIGN: 2002-2003 (NOT YET COMPLETELY FINISHED)
Design life - the minimum length of time the beach management scheme is designed to last.	15 YEARS
Which tools and regulations are used for the design formulae (mathematical models, model tests, engineering experience, standards, recommendations).	MATHEMTICAL MODELS, ENGENEERING EXPERIENCE, STANDARDS
Who fund the work (e.g. Public Administration or private company)?	PUBLIC ADMINISTRATION
Costs.	

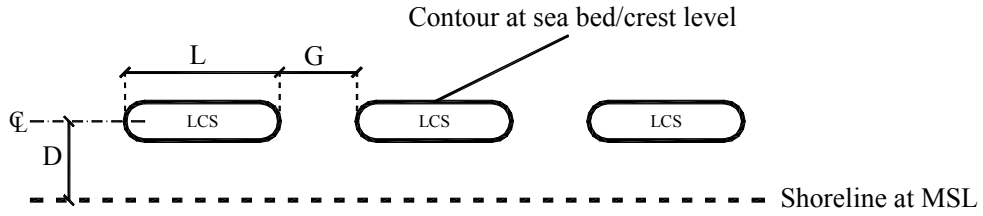

OPERE IN PROGETTO
OPERE IN COSTRUZIONE
LCS8
G8
LCS7
G7
LCS6
G5
LCS5
G4
LCS4
G3
LCS3
G2
LCS2
G1
LCS1
4
3
2
1
profilo B
profilo A
limite rilievo linea di riva 1999
linea di riva 1997
canale Molino
campigny
scala 1:5000
0
100
200
300
400
500

B: Geometry and construction materials

B1 System layout (aerial view)

Are shore attaching structures present (e.g. groins)?	■ Yes ☐ No
Are emerging head islands present?	☐ Yes ■ No

The following sketch concerns only shore parallel LCS; if the layout is different you must insert another sketch and specify parameters like the ones suggested. If a picture is available please insert it too.



The typical layout is given at Sea Bed (index SB) and at Crest Level (index CL).

Parameter	Description	Fill in box	Unit
D	Distance from shoreline	250	Meters
L_{SB}	Length of LCS at sea bed	2450+360	Meters
L_{CL}	Length of LCS at crest level	LCS1: 315 LCS2: 360 LCS3:320 LCS4: 455 LCS5:193 LCS6: 297 LCS7: 390 LCS8: 340	Meters
G_{SB}	Gap between LCS at sea bed		Meters
G_{CL}	Gap between LCS at crest level	G1:20 G2: 15 G3: 20 G4: 30 G5: 15 G6: 20 G7:20	Meters
n	Number of LCS in system	8	

Remarks

The first design included 7 LCS elements, in all 2450 m long, with 6 gaps, some with a protection placed 10 m leeward from the gap not constructed because caused risk to small boats sailing in the gap. At the end of the work, was added a second design of a submerged

barrier 360 meters long and a groin, so all the protected area in 2001 was divided in 4 cells. In 2002, with a third design were realised: occlusion of 5th gap, reduction and raising of 4th gap, division of the second cell with a submerged cross-shore barrier (South side of Canale Molino).

B2 Bathymetry of sea bed and beach

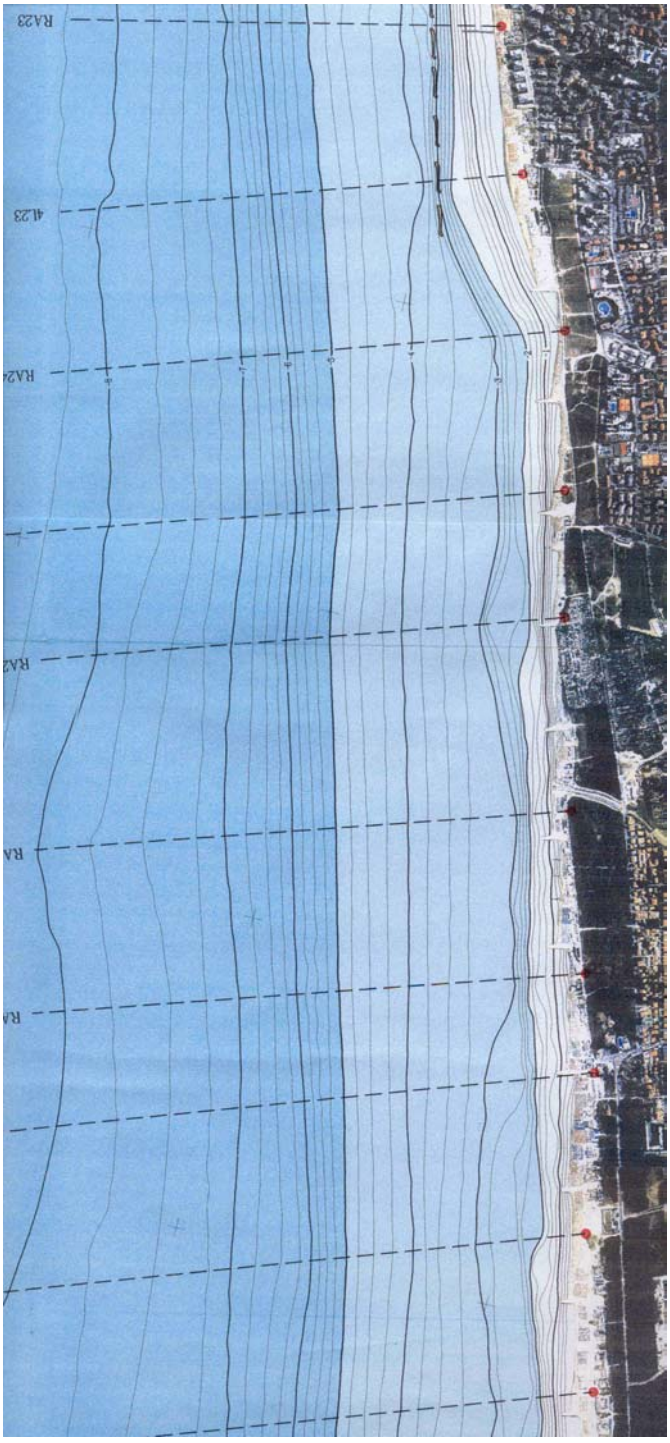
Please insert a dimensioned sketch if possible.

Description of bathymetry when LCS were build

Is detailed information (measurements) available? If so, please explain.

Seabed was characterized by a quite high slope between the shore line and the –4 / -6 m isobath. Slope decreased off-shore, with maximum values of 0.8%.

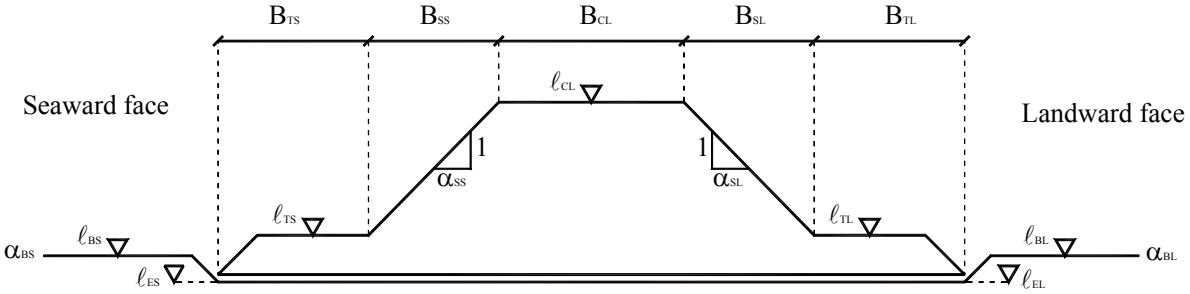
Slope was generally esteemed in 6:1000, that became 1:1000 in the band contained between 7-10 m depth.



scale 1:20000

B3 Trunk cross section/contour geometry – outer profile

If shore attached structures perpendicular to shoreline are present, please insert a sketch with typical longitudinal section and typical selected cross sections. Specify parameters as the ones given below. If the layout does not fit the following sketch please insert another sketch.

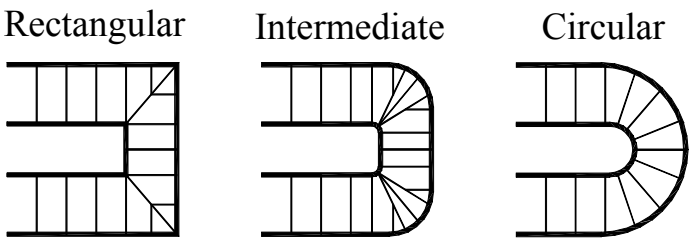


Parameter	Description	Fill in box	Unit
α_{BS}	Steepness of sea bed, seaward	1:250	
α_{BL}	Steepness of sea bed, landward		
α_{SS}	Steepness of slope, seaward	1:2	
α_{SL}	Steepness of slope, landward	1:1.5	
ℓ_{BS}	Level of sea bed at seaward toe	-3.05	Meters
ℓ_{ES}	Level of excavation, seaward		Meters
ℓ_{TS}	Level of toe, seaward	-1.80	Meters
ℓ_{CL}	Level of crest	-0.50	Meters
ℓ_{BS}	Level of sea bed at landward toe	-2.95	Meters
ℓ_{ES}	Level of excavation, landward		Meters
ℓ_{TS}	Level of toe, landward	-1.80	Meters
B_{TS}	Width of toe, seaward	2	Meters
B_{SS}	Width of slope, seaward	2.4	Meters
B_{CL}	Width of crest	12	Meters
B_{SL}	Width of slope, landward	3.2	Meters
B_{TL}	Width of toe, landward	2	Meters

Remarks (e.g. different layout along shoreline, other important parameters).

Crest was built at –0.20 m. depth from mean water level, but the design level of crest is of –0.50 m. depth because of the settlement of the blocks.

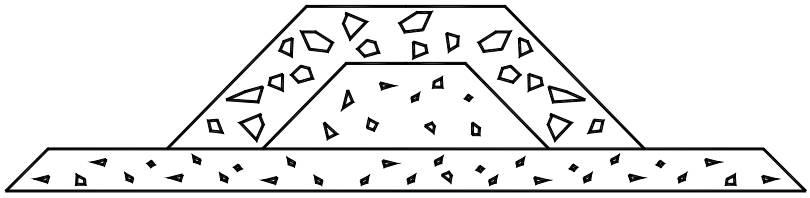
B4 Round head contour geometry



What is the shape of the round head?
☐ Rectangular
☐ Intermediate
■ Circular

B5 Description of layers

Please insert a dimensioned sketch with the typical cross-section composition.



For each layer, please provide the following information.

ARMOUR

Parameter	Description	Fill in box	unit
	Material (e.g. quartzite, concrete)	Limestones and calcareousrocks	
	Shape of blocks (e.g. quarry rock, sea stones, cubes)	Quarry rock	
ρ_r	Mass density of material	2600	Kg/m^3
D_{n50}	Nominal diameter	I CAT: 0.60 II CAT: 0.90	Meters
Gr	Grading of the material (D_{85}/D_{15})		
	Geotextile between layers?	☐ Yes ■ No	

BEDDING LAYER

Parameter	Description	Fill in box	unit
	Material (e.g. quartzite, concrete)	Limestones	
	Shape of blocks (e.g. quarry rock, sea stones, cubes)	Mixed quarry	
W	Weight of blocks	50% weight < 50 50% weight 50-500	Kg
ρ_r	Mass density of material		Kg/m^3
D_{n50}	Nominal diameter		Meters
Gr	Grading of the material (D_{85}/D_{15})		
	Geotextile between layers?	☐ Yes ■ No	

Remarks (e.g. details on geotextile)

B6 Construction method

How have the stones been placed?

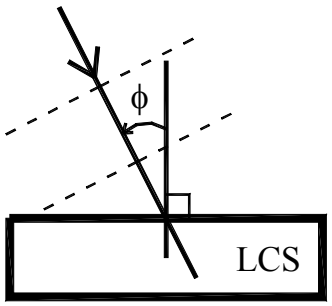
- ■ Dumped with barges
- ■ Placed with barges
- ☐ Land based operation
- ☐ Other:

Sequence of operation.

- ☐ Construction started upstream
- ■ Construction started downstream

C: Local meteomarine conditions at the structure

C1 Waves



Parameter	Description	Fill in box	Unit
H_S	Design significant wave height	5.8	Meters
T_P	Design peak period	10.5	Seconds
ϕ	Design wave incidence angle	0	Radians

Remarks (provide information on wave statistics and wave spectra if available, e.g. H_S corresponding to return periods 1 month, 1 y, 10 y, 50 y. Please specify the source of the data)

Wave data come from observations and gauges at AGIP platforms, in particular: observations performed at PCB platform cover the period between 1970 and 1983; data are measured at three platforms in North Adriatic: Amelia, Garibaldi and PCB.

From the examination of PCB data, acquired between 1970-1983, it is possible to determine significant values of wave heights and periods, as shown in the following table.

The predominant winds in this area are Bora and Scirocco. The first one comes from E-NE and reaches largest frequency during the cold season, while Scirocco wind, coming from SE, is more intense in autumn and in spring. The most frequent storm events are caused by Scirocco (about 120°), and the most intense comes from NE direction.

TR	1 YR		2 YRS		5 YRS		10 YRS		25 YRS		50 YRS		100 YRS	
Dir	**Hs**	**Ts**	**Hs**	**Ts**	**Hs**	**Ts**	**Hs**	**Ts**	**Hs**	**Ts**	**Hs**	**Ts**	**Hs**	**Ts**
60° (Bora)	3.6	7.4	4.0	7.8	4.5	8.1	4.9	8.3	5.4	8.7	5.8	9.0	6.2	9.2
90° (Levante)	3.5	8.4	3.9	8.7	4.4	9.1	4.9	9.6	5.4	10.1	5.8	10.5	6.2	10.7
120° (Scirocco)	2.8	7.8	3.3	8.4	3.8	8.9	4.2	9.4	4.7	9.9	5.1	10.3	5.5	10.8

C2 Water levels

Tidal water level variations

Parameter	Description	Fill in box	Unit
HAT	Highest astronomical tide level		Meters
MHWL	Mean tide high water level	0.40	Meters
MWL	Mean water level	0.0	Meters
MLWL	Mean tide low water level	-0.40	Meters
LAT	Lowest astronomical tide level		Meters

Water level statistics (If available, please provide information on design water level and tide and surge generated water levels corresponding to return periods 1 month, 1 y, 10 y, 50 y)

See the following table.

T_R	2.5	5	10	25	50	100
Max. level	+0.88	+0.93	+0.95	+0.97	+1.03	+1.12
Min. level	-0.77	-0.82	-0.85	-0.86	-0.87	-0.90

C3 Current

Tidal currents

Description & statistics if available

Littoral current direction: from N-NW.

Surge generated currents

Description & statistics if available (e.g. mean velocities as function of water depth/distance to shore line)

D: Sea bed and beach characteristics, incl. sediment transport

Description of the coast (e.g. bar type coast with gentle slope or plane coast with steep slope)

Punta Marina is located between the outlet of Fiumi Uniti river and the Corsini harbour; the coastal continuity is broken by some channel outlets such as Canale Molino. The coastal morphology, everywhere low and plane, is characterized by sandy beaches lying over clay banks.

D1 Sea bed material at surface

Parameter	Description of sea bed material	Fill in box	Unit
	Material (e.g. quartzite)	Natural sand	
ρ_r	Mass density of material		Kg/m^3
D_{n50}	Nominal diameter grain size	$0.18*10^{-3}$	Meters
Gr	Grading of the material (D_{85}/D_{15})		

Remarks (provide grain distribution if available)

See the following table.

DEPHT (M)	SAND %	CLAY %	DIAMETER (MM)	STANDARD DEV.	ASYM.	KURTOSI
0.0	98.9	1.1	0.204	0.55	-0.01	1.00
-1.0	99.7	0.3	0.133	0.34	0.1	0.97
-3	98.0	2.0	0.093	0.28	0.04	0.96
-6	98.0	2.0	0.087	0.28	0.03	0.97

D2 Beach material at surface

Parameter	Description of beach material	Fill in box	Unit
	Material (e.g. quartzite)	Natural sand	
ρ_r	Mass density of material		Kg/m^3
D_{n50}	Nominal diameter grain size	$0.2264*10^{-3}$	Meters
Gr	Grading of the material (D_{85}/D_{15})	2.43	

Natural supply?	■ Yes ☐ No
Supplied by beach nourishment?	■ Yes ☐ No

Remarks (provide grain distribution if available)

D3 Sediment transport

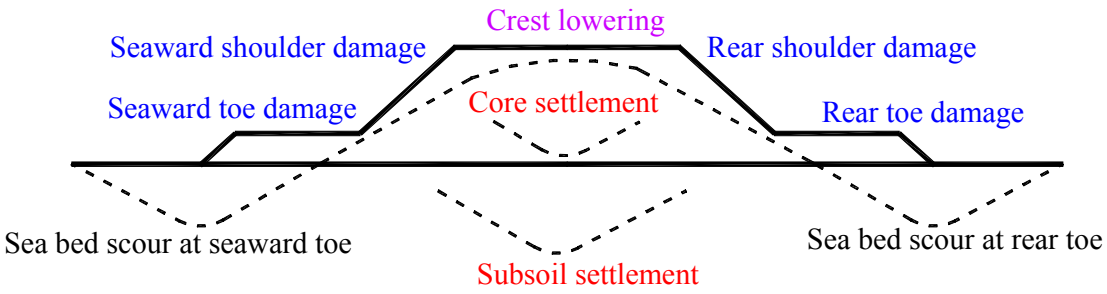
Description of the sediment transport (e.g. direction and amount of transport, distribution over the coastal profile) The most important sediment transport occurs between shoreline and –6 m depth, the predominant direction is from South to North; it is due by saltation and rolling leeward and by suspension offshore. The emergent barriers in front of Lido Adriano catch the most part of sediments coming from South. Data from Idroser 1996 shown that resultant longshore transport is -27.0*10^3 m^3/anno

The following parameters must be completed only if artificially nourished and different form sea bed material.

Parameter	Description of artificial sediment	Fill in box	unit
	Material (e.g. quartzite)		
ρ_r	Mass density of material		Kg/m^3
D_{n50}	Nominal diameter		meters
Gr	Grading of the material (D_{85}/D_{15})		

E: Structural performance

E1 Definition of failure modes



Please e-mail a sketch with dimensions of LCS cross-section when it was build compared to the appearance now (like the figure of failure modes) if possible. If so, please type the filename in the box.	

In the following please specify damages by failure mode (see figure of failure mode definition) and amount of damage. If you know the reason for the problems/failures (e.g. extreme wave climate/water level), please type it in the description boxes.

E2 Materials

Problems caused by deterioration?	☐ Yes ☐ No
Problems caused by breakage?	☐ Yes ☐ No

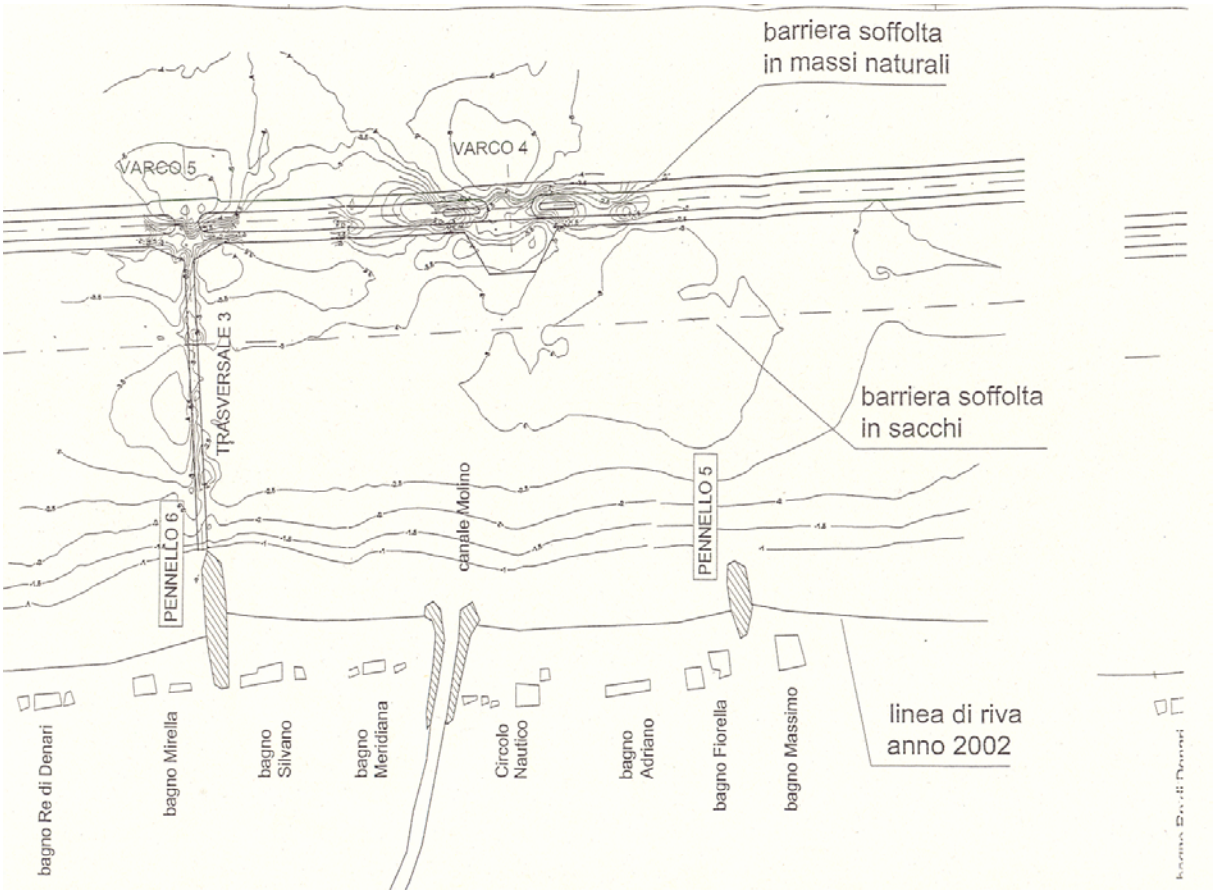
Description of the condition of the materials

E3 Settlement of the structure

Description of settlements of core/subsoil (e.g. instabilities in foundation, internal erosion). Please specify settlement in meters.

E4 Local erosion of sea bed/scour

Description of erosion/scour by roundheads (please specify scour depth) Erosion is visible around the roundhead of the structures because of the hydrodynamic circulation that is created during sea-storm; in particular around the 4^{th} gap, in front of Canale Molino. See the following sketch wich explains 4^{th} and 5^{th} gaps bathymetry.
Description of erosion/scour by trunk (please specify scour depth)



E5 Erosion and instability of slopes, shoulders, crest and toes

Stage of damage
☐ No or marginal damage
☐ Moderate to severe damage
☐ Failure

Description of displacements of structural material (provide sketch if possible)

E6 Damage parameters

The definition of a displaced unit is, when a unit is displaced by more than D_{n50}.
Try to give an estimate of the following damage parameters relevant to armour.

Parameter	Description	Fill in box	unit
The relative number of displaced units	$D(\%) = \frac{n_d\,(\text{number of displaced units})}{\text{Total number of units}} \cdot 100$		%
The strip displacement	$N_{od} = \frac{n_d}{L / D_{n50}}$, L is the length of LCS		

F: Socio-economic aspects

What regime of property has the coast at this site?
Private ☐, Public full free access ■ Public limited access ☐, Natural reserve ☐, Don't know ☐,
Other (please specify):

Who decided that an LCS should be built at that site?
Individual, acting for private purpose ☐
Individual, acting for public purpose (e.g. Natural park administrator) ☐
Local authority (e.g. city council) ■
Regional authority (e.g. province level) ☐
National authority (e.g. ministry) ☐
Don't know ☐
Please give name of the authority whenever applicable:

What was the main motive for building the LCS?
Coast erosion ■
Inducing or maintaining recreational activity ■, please specify:
Environmental concern ☐, please specify:
Other ☐, please specify:
Don't know ☐

Was that LCS part of a larger coastal management plan?
Yes ■, please specify:
No ☐, please specify:
Don't know ☐

Public opinion on that LCS:
Construction was accompanied by public protest ☐
The public did not react ☐
Public opinion asked for the LCS ☐
Local commerce asked for the LCS ☐
Don't know ☐
Other (please specify):

Description of the coast:
Urban ☐, Densely constructed ■, Scarcely constructed ☐, No apparent construction ☐

Are there dunes? Yes ■, No ☐
Has commercial activity changed significantly after construction of the LCS?
hotels construction: More hotels ☐, Less hotels ☐, Unaffected ☐, Don't know ☐
bars and similar construction: More ☐, Less ☐, Unaffected ☐, Don't know ☐
advertising for the area: More ☐, Less ☐, Unaffected ☐, Don't know ☐
other (specify):

Visual impact of LCS not already described in Part B: Are there parts of the LCS visible under average conditions? Poles ☐, Cables ☐, Reefs ☐,
Others (please specify):

Water quality changes since LCS construction
Are there episodes of water turbidity since construction?
No ■, Rare ☐, Often ☐, Permanent ☐
Were there episodes of water turbidity before construction?
No ■, Rare ☐, Often ☐, Permanent ☐
Has water quality otherwise been affected (for example, more or less detritus accumulating)?
Please describe:

How would you qualify the following recreational activities at or around the LCS? (DK = Don't know)

Fishing (recreational)	Intense ☐	Moderate ☐	Scarce ■	Absent ☐	DK ☐
Seafood collecting	Intense ☐	Moderate ☐	Scarce ■	Absent ☐	DK ☐
Wildlife watching	Intense ☐	Moderate ☐	Scarce ☐	Absent ■	DK ☐
Sunbathing and similar	Intense ■	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Scuba diving	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Sailing and similar	Intense ☐	Moderate ■	Scarce ☐	Absent ☐	DK ☐
Other (specify)	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐

Could you describe those recreational activities before the LCS was built? (DK = Don't know)

Fishing (recreational)	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Seafood collecting	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Wildlife watching	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Sunbathing and similar	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Scuba diving	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Sailing and similar	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐
Other (specify)	Intense ☐	Moderate ☐	Scarce ☐	Absent ☐	DK ☐

Has that LCS had an environmental impact assessment before being built? Yes ☐, No ☐, Don't know ☐
Could you give its references and location (specify)?

Has there been an economic study on that LCS,
before it was built? Yes ☐, No ☐, Don't know ☐, References:
after it was built? Yes ☐, No ☐, Don't know ☐, References:

G: Ecological aspects

What are the dominant species on the structures?

In all, 180 species of phytoplankton are been identified, in particular: 190 *Dinoflagellata*, 50 *Diatoma*, 12 *Chlorophyceae*, 3 *Sicoflagellata*? The seasonal dynamics of phytoplankton population is characterized by: *Thalassiosira decipiens* (January – February), *Skeletonema*

costatum (February – June and July – September), *Nitzschia delicatissima* (March – May), *Procentrum micans* (April – June), *Chetocerus spp.* (May – July), *Rhizosolenia alata* (June – July), *Peridinium throcoidenum* (July – October), *Gonyaulax poliedra* (August – October), *Gymnodinium sp.* (September – December).

In the coastal zone the mostly present macroalgae are: *Ulva* spp. and *Enteromorpha* spp.

What are the dominant species in the sediment and fish assemblages around the structures?

Macrobenthic assemblages are dominated by the bivalve *Chamelia gallina.* Other abundant species are: *Oweenia fusiformis*, *Capitella capitalia*, *Lentidium mediterrneum*, *Magelona papillicornis.*

Were any environmental changes observed following the construction of the structure (e.g. increase of water turbidity, floating algal debris)?

H: Coastal protection performance

H1 Bathymetry and beach evolution

Description of historical beach evolution before LCS was built (10-20 years).

Erosion of the coast in the whole area mainly due to reduced fluvial transport and subsidence. Anthropic subsidence, mainly due to water and gas extraction, between 1986 and 1992 was about 0.6-1.0 cm/year.

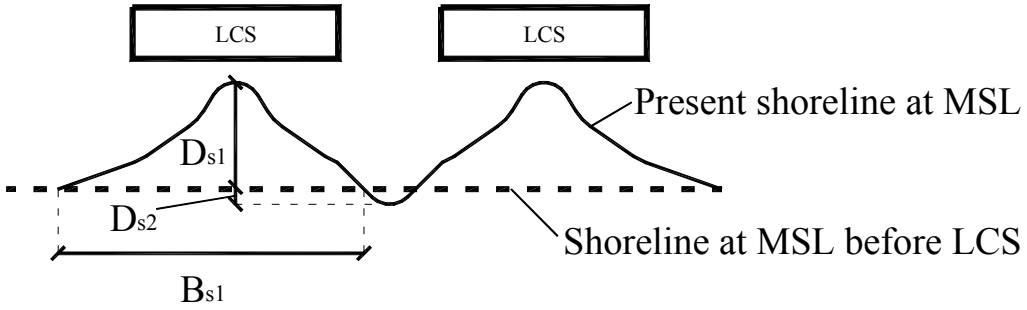
Description of beach evolution after LCS was built up to now.

After LCS was built, shoreline advances everywhere, raising in some points 40-50 m.

Water quality is everywhere good and fine sediments are not present leeward.

H2 Salient formation

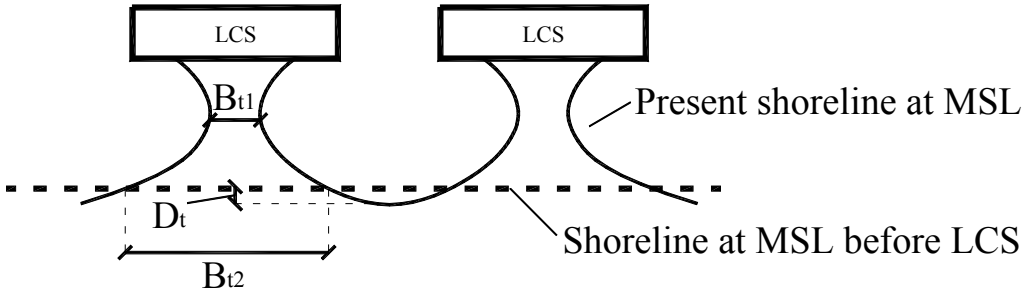
No salient formation



Parameter	Description	Fill in box	unit
D_{s1}	Max distance between new and old shoreline, seaward		meters
D_{s2}	Max distance between new and old shoreline, landward		meters
B_{s1}	Width of salient at old MSL		meters

H3 Tombolo formation

No tombolo formation.



Parameter	Description	Fill in box	unit
D_t	Distance between new and old shoreline, landward		meters
B_{t1}	Minimal width of tombolo		meters
B_{t2}	Width of tombolo at old MSL		meters

H4 Renourishment

Description of renourishment (add more fill) (e.g. amount, how often) 2001: 100M m^3 nourishment of sand employing two typology of sandy sediment with D_{n50}=0.20 and D_{n50}=0.26. Poured material, starting from 1.5 m. under mean water level,

creates a beach with an advanced shoreline of 20-25 m.

2002: 40M m^3 nourishment in the North side of barriers.

2003: will be nourished: 25M m^3 in front of Canale Molino, 30M m^3 next to the final zone (North side).

H5 Down drift erosion

Please insert a sketch if relevant.

Description of down drift erosion (morphological impact, e.g. down drift erosion length and maximal down drift shoreline retreat)

I: Problems in general

Description of other problems/impacts

Localized signs of erosion are visible near the barrier seaward and landward because of strong currents off-shore in front of the largest gaps. In order to limit current intensity, the third design proposed: division of the second cell with a submerged cross-shore barrier (South of Canale Molino), occlusion of 5^{th} gap and reduction of 4^{th} gap. At the end of the work will be nourished 25M m^3 of sand.

Near 6^{th} groin Northside is visible a backing of shoreline, so will be nourished 70M m^3.

In the beginning zone, next to the first groin, shoreline decreases and there will be constructed a new submerged cross-shore barrier, and the second gap will be removed.