DELTAS
IN TIMES OF CLIMATE CHANGE

ROTTERDAM 2010

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THE UNIVERSITY OF SYDNEY

CLIMATE CHANGE V ANTHROPOGENIC EFFECTS ON UNCERTAINTY

TIBER DELTA EROSION

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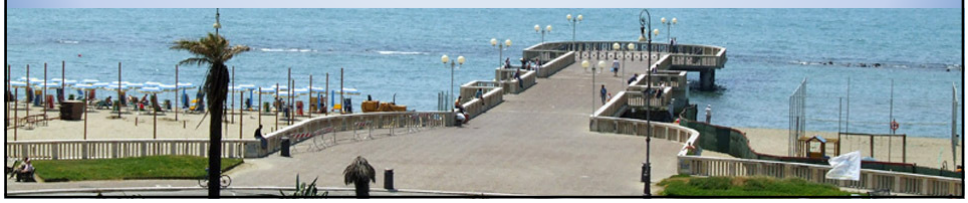
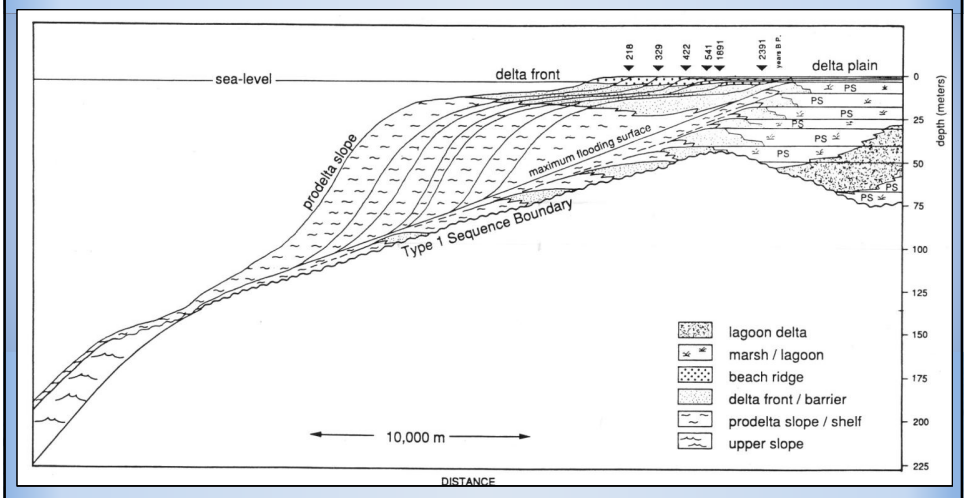


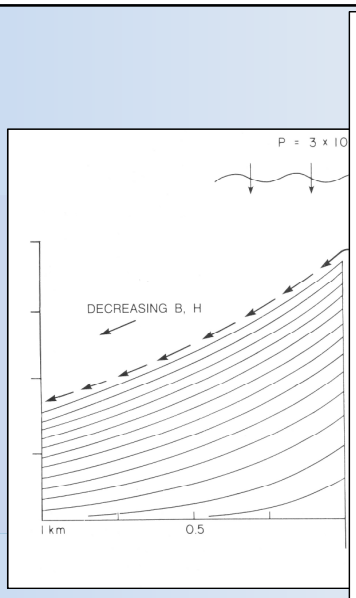
Outline

1. Tiber delta development
2. Present shoreline status
3. Forecasts of coastal recession
4. Uncertainty analysis

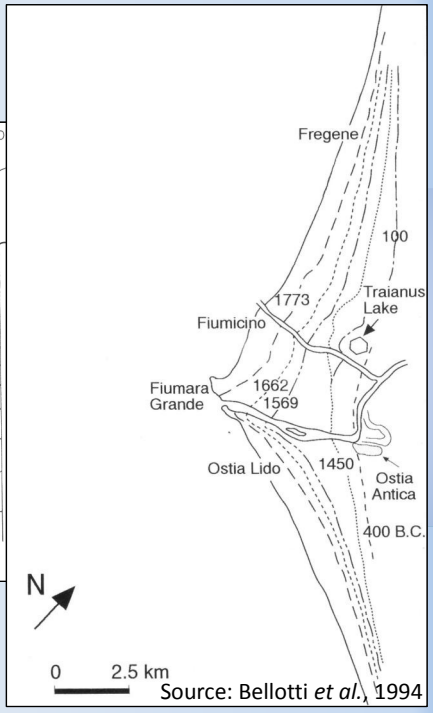
Tiber Delta development



Source: Bellotti *et al.*, 1994

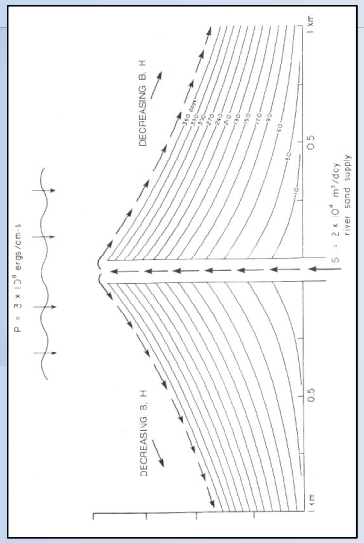


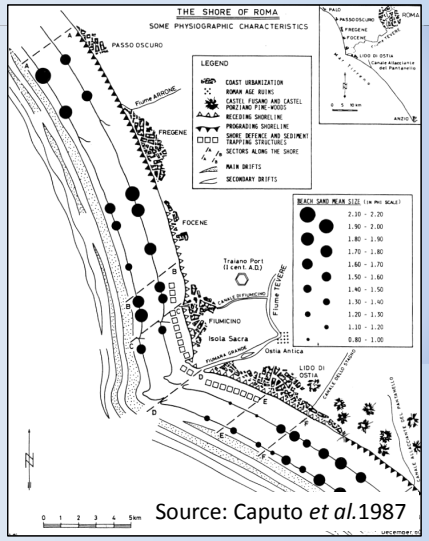
Source: Komar, 1973



Source: Bellotti *et al.*, 1994

Present shoreline status



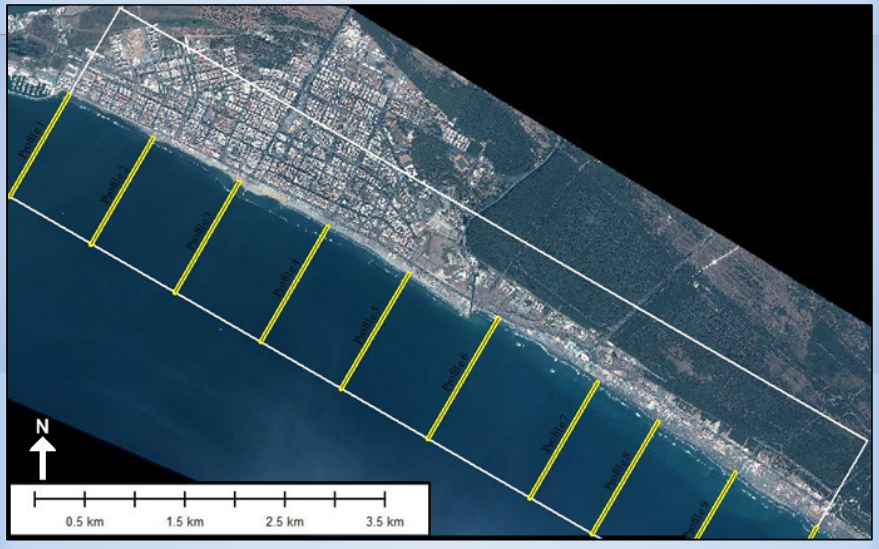


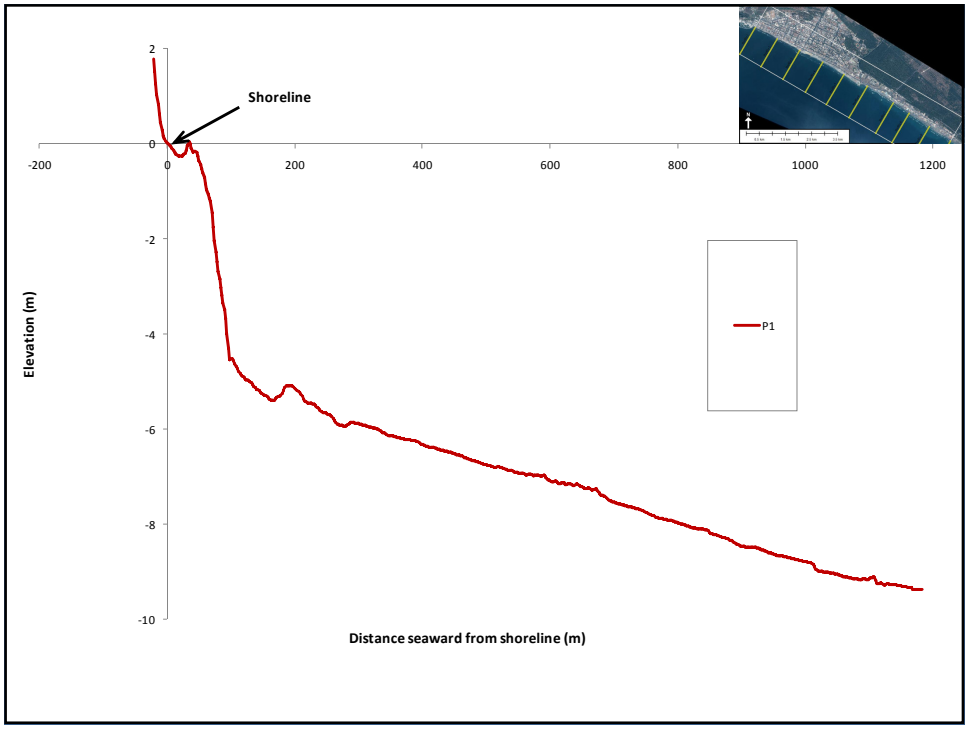
Source: Caputo *et al.*1987

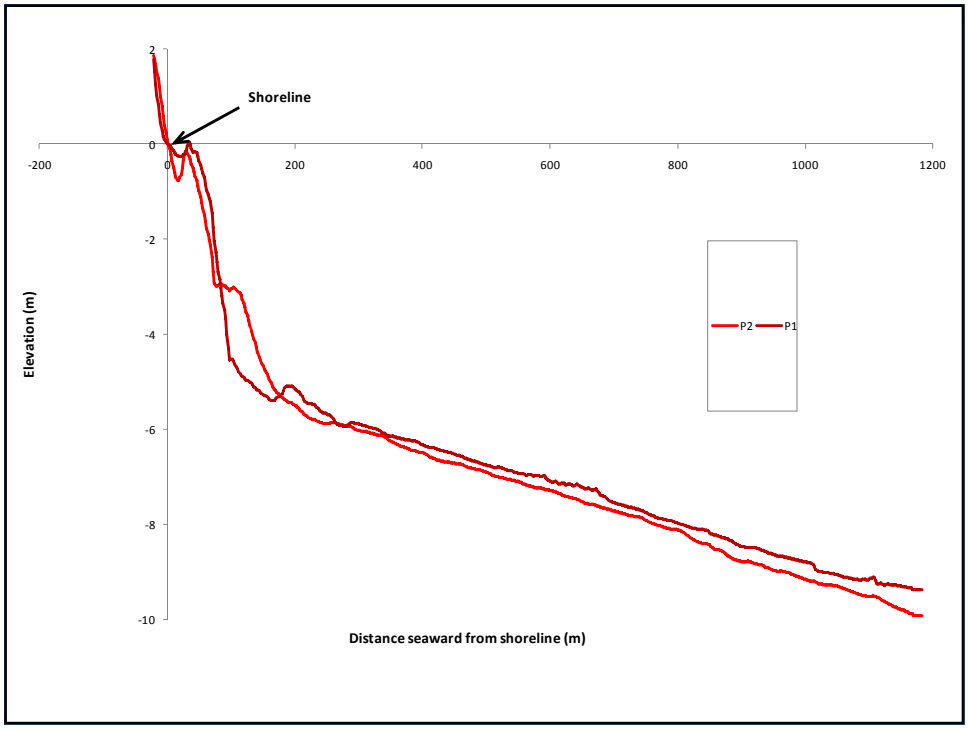
Interventions

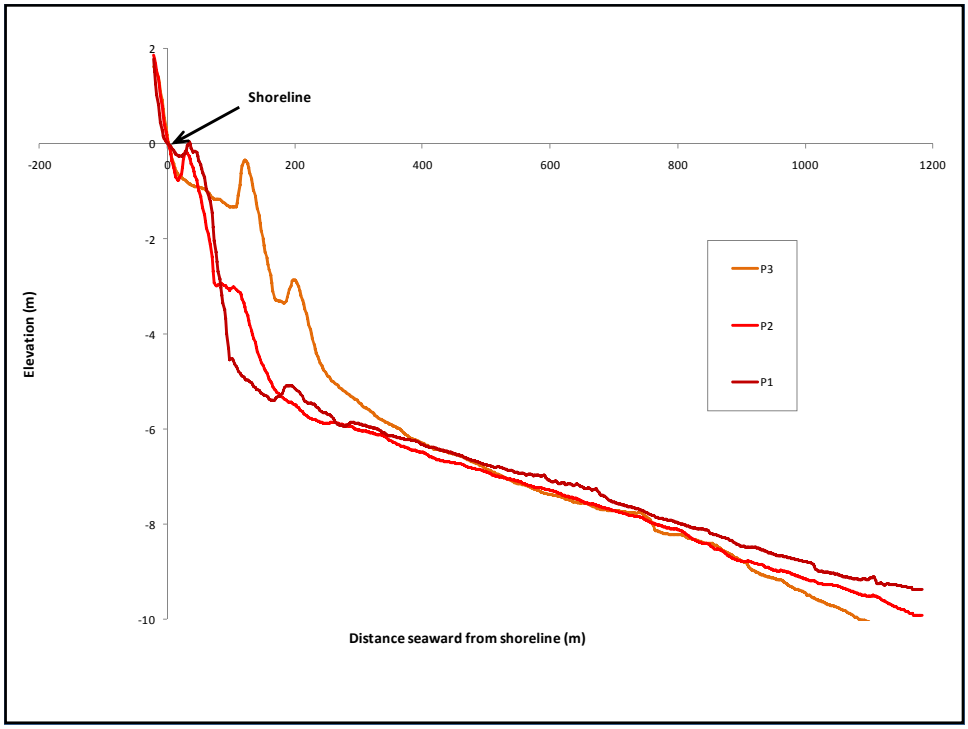
- Submerged breakwaters
- Nourishment
- Cross-shore dykes & sandbags
- Sea wall
- Training walls/jetties
- Port construction

Bathymetric profiles




Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P1


Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P2
P1


Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
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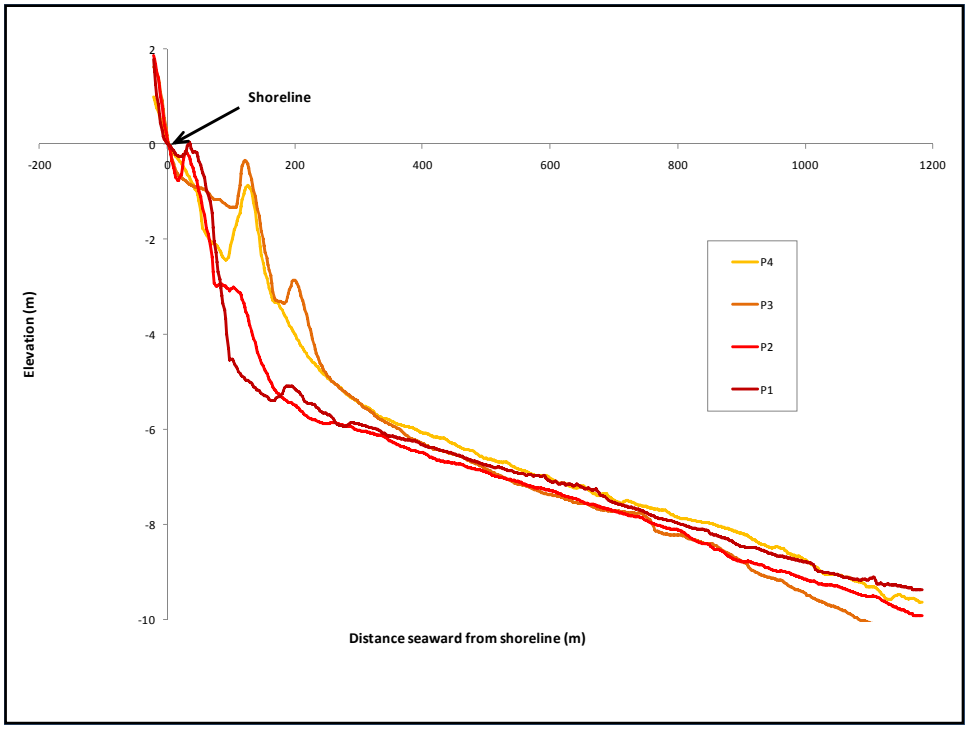
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P3
P2
P1


Shoreline
2
0
-2
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-6
-8
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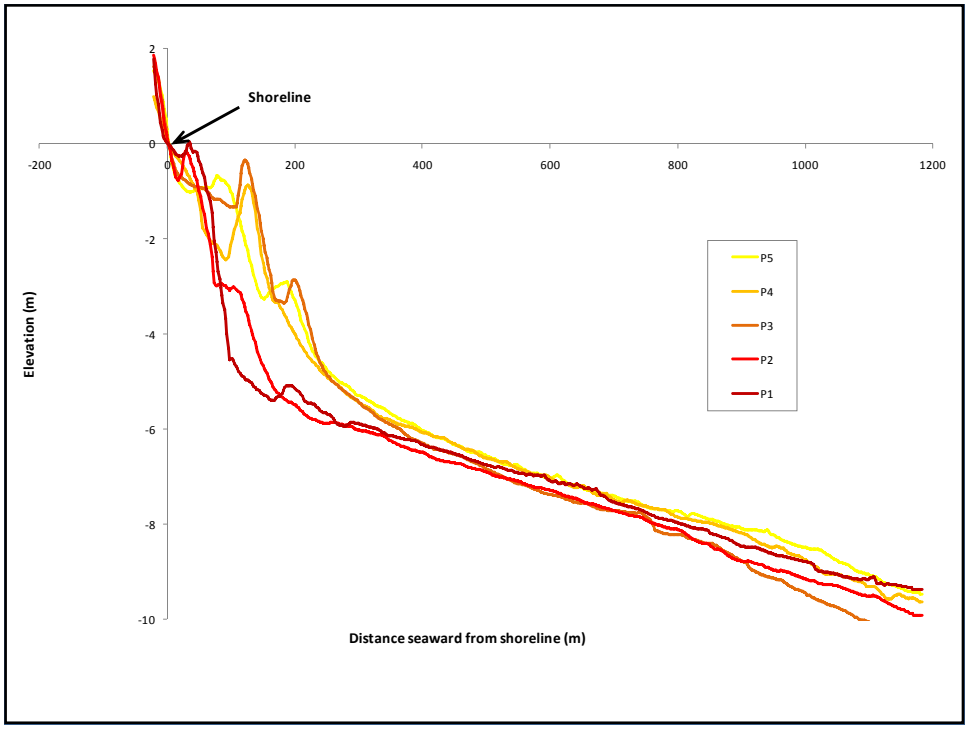
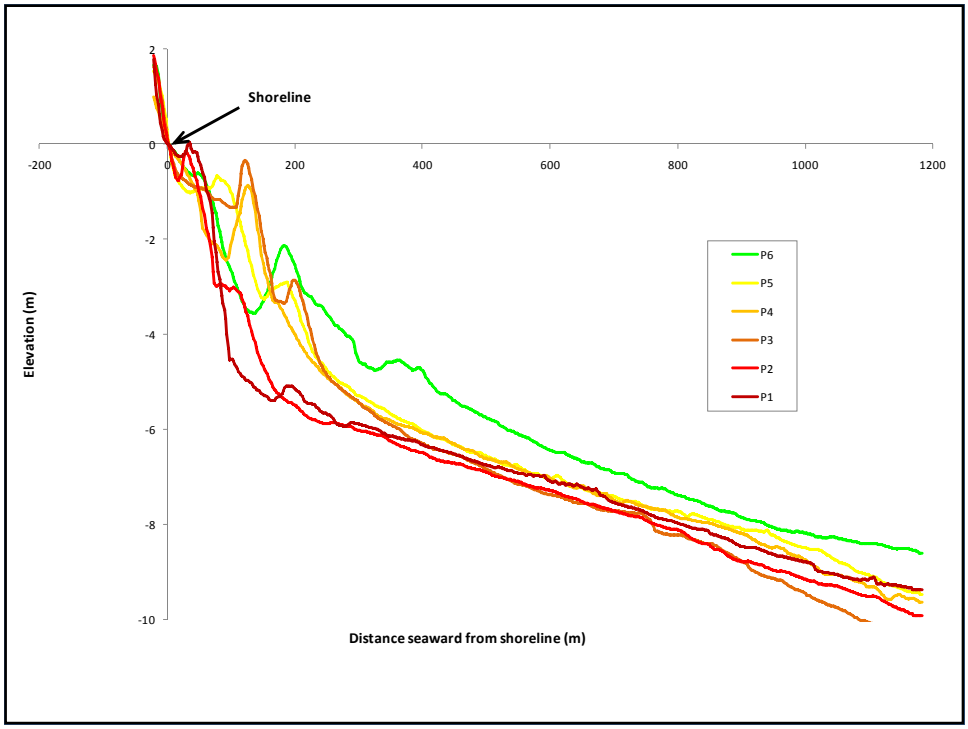
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P4
P3
P2
P1


Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P5
P4
P3
P2
P1


Shoreline
2
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-200
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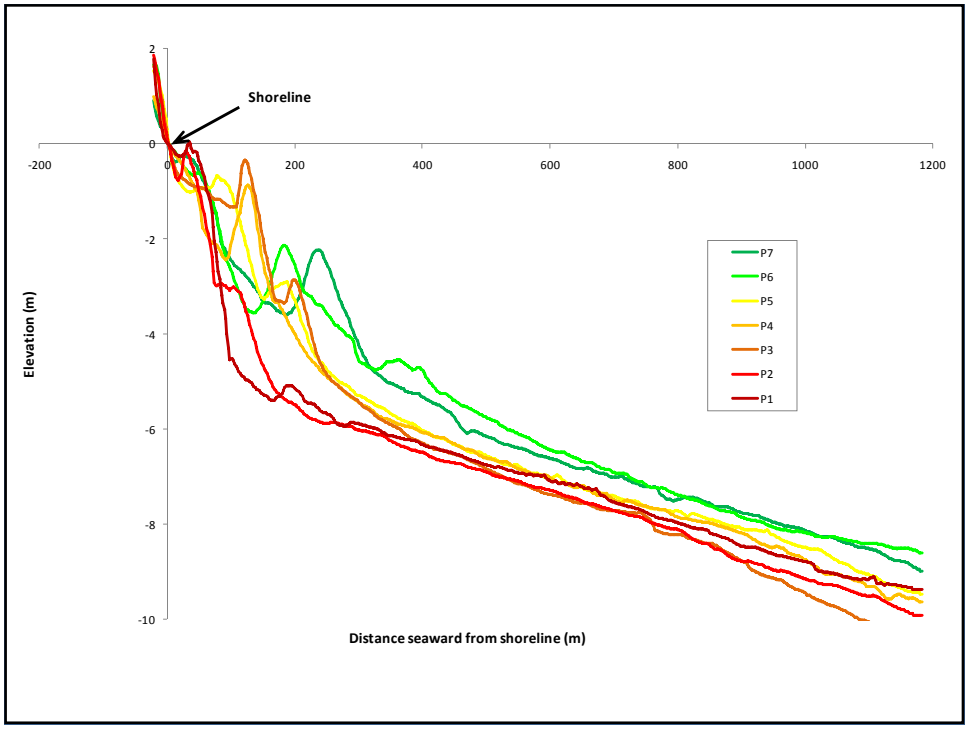
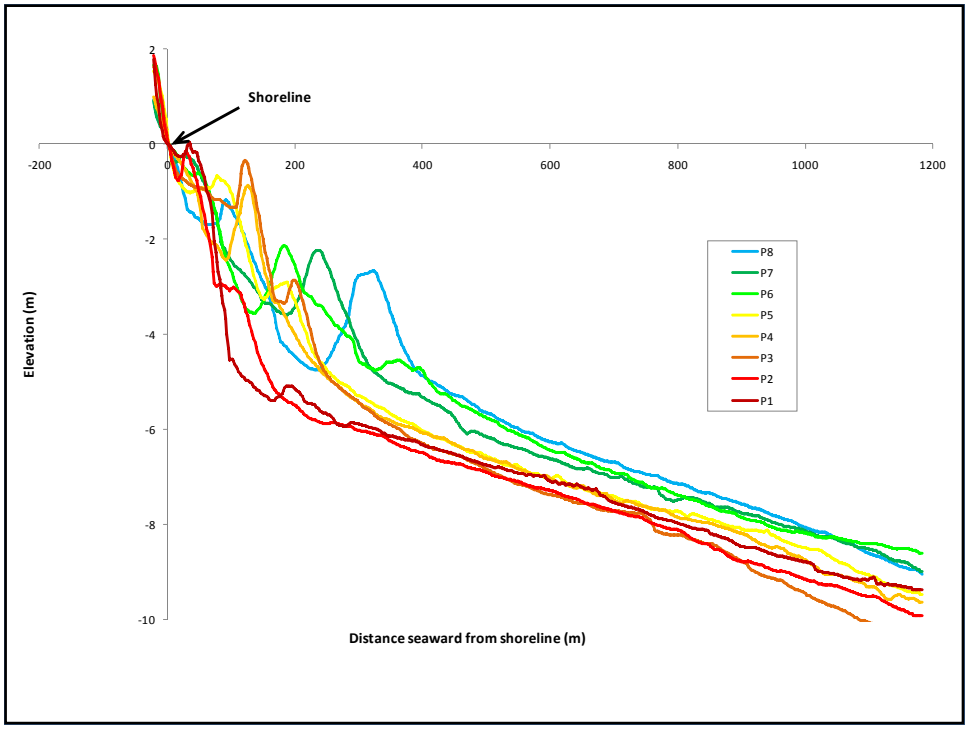
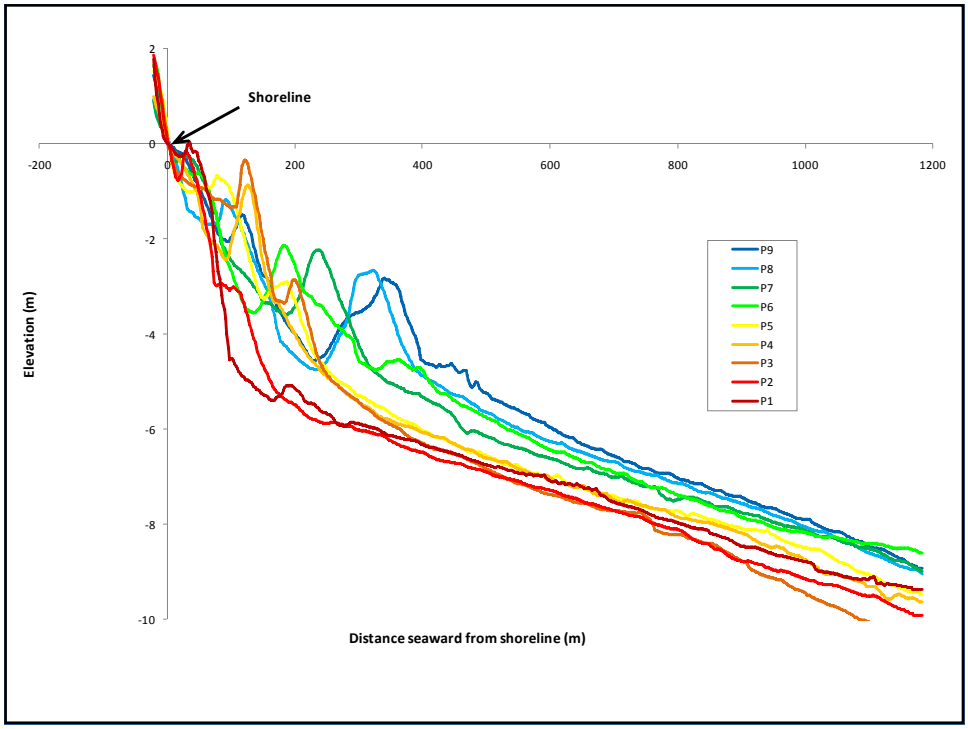
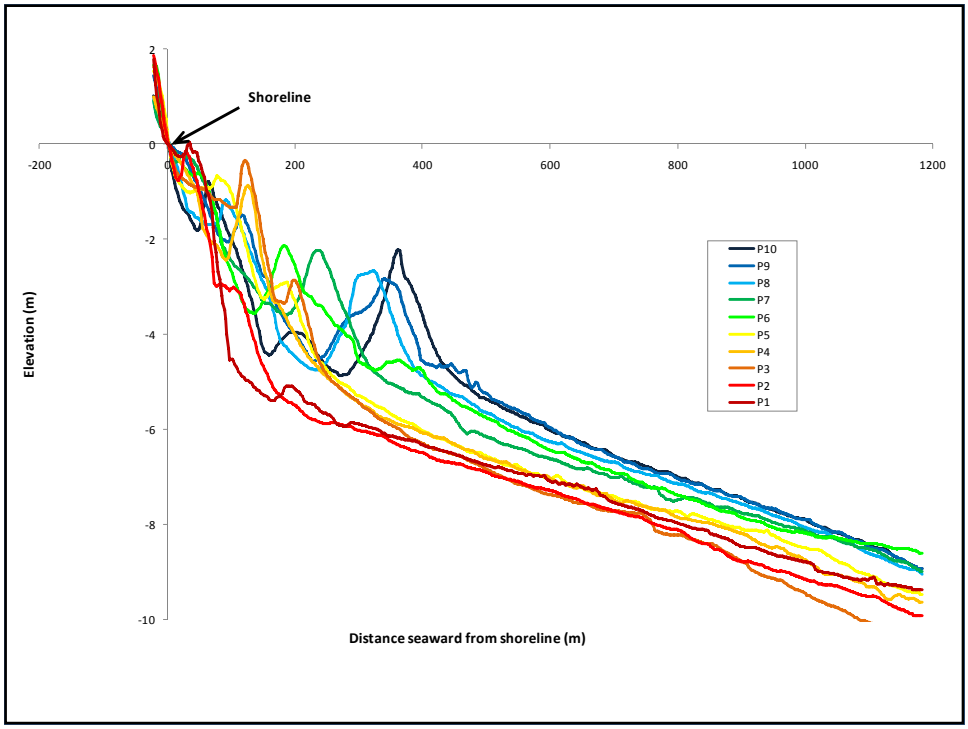
Elevation (m)
Distance seaward from shoreline (m)
P6
P5
P4
P3
P2
P1

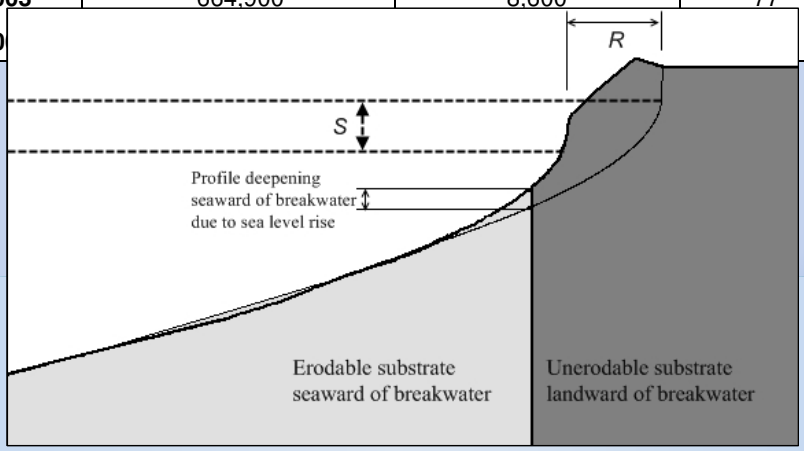

Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P7
P6
P5
P4
P3
P2
P1

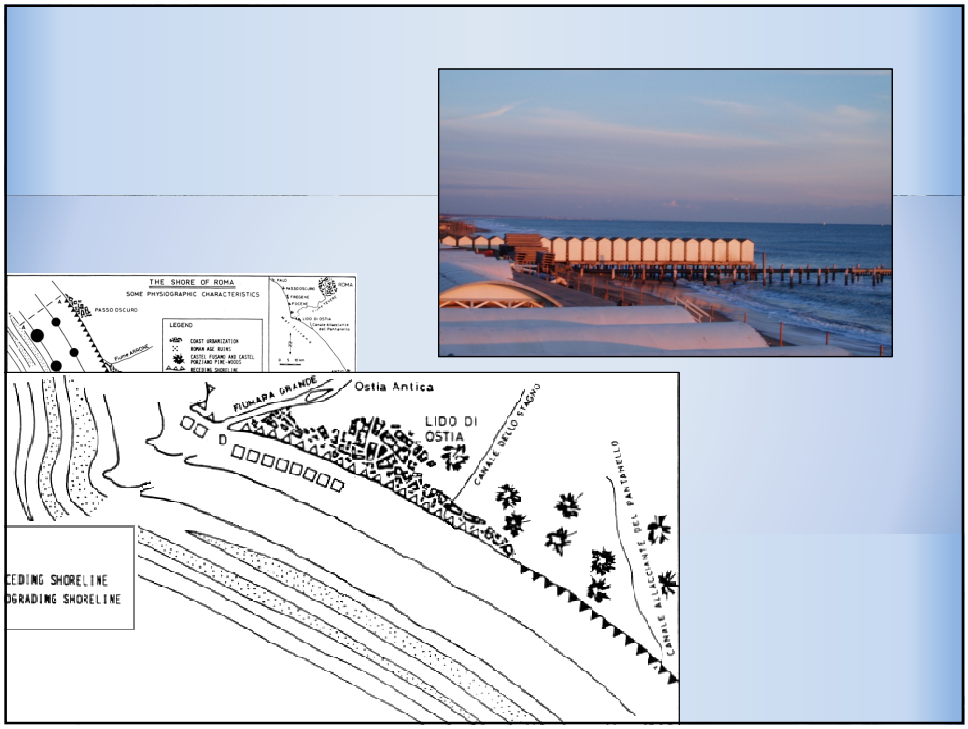

Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P8
P7
P6
P5
P4
P3
P2
P1

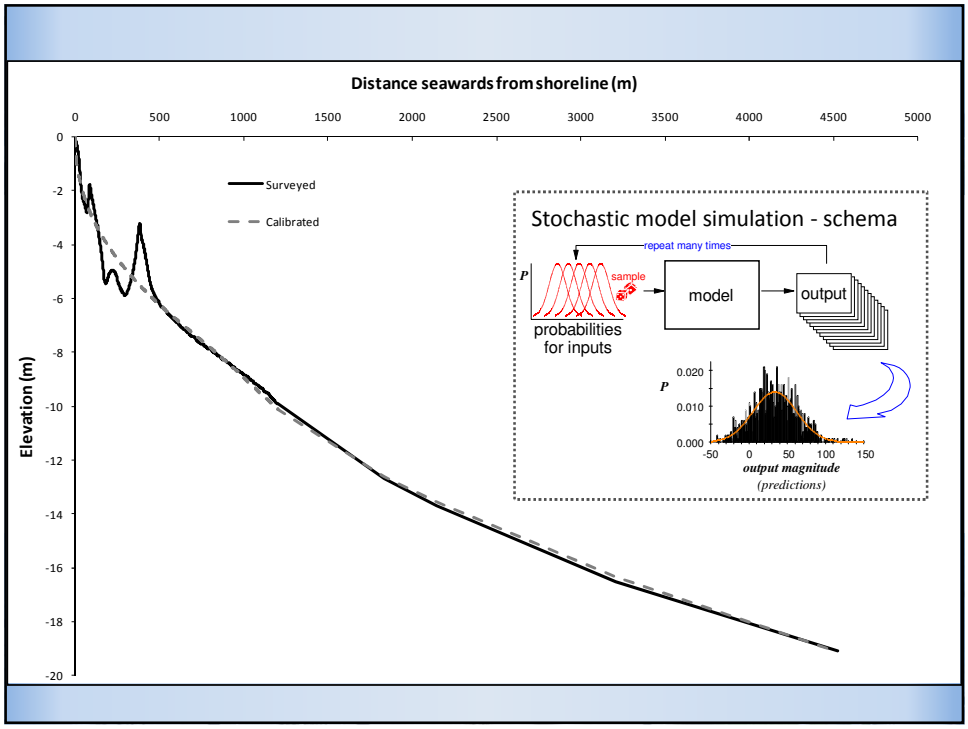

Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P9
P8
P7
P6
P5
P4
P3
P2
P1

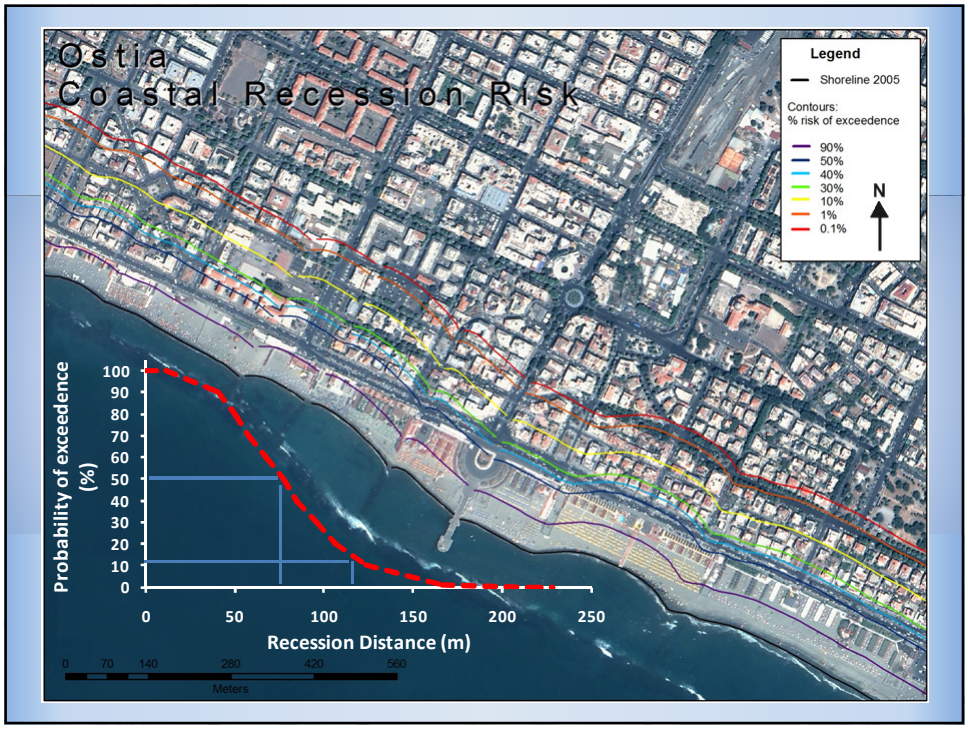

Shoreline
2
0
-2
-4
-6
-8
-10
-200
0
200
400
600
800
1000
1200
Elevation (m)
Distance seaward from shoreline (m)
P10
P9
P8
P7
P6
P5
P4
P3
P2
P1

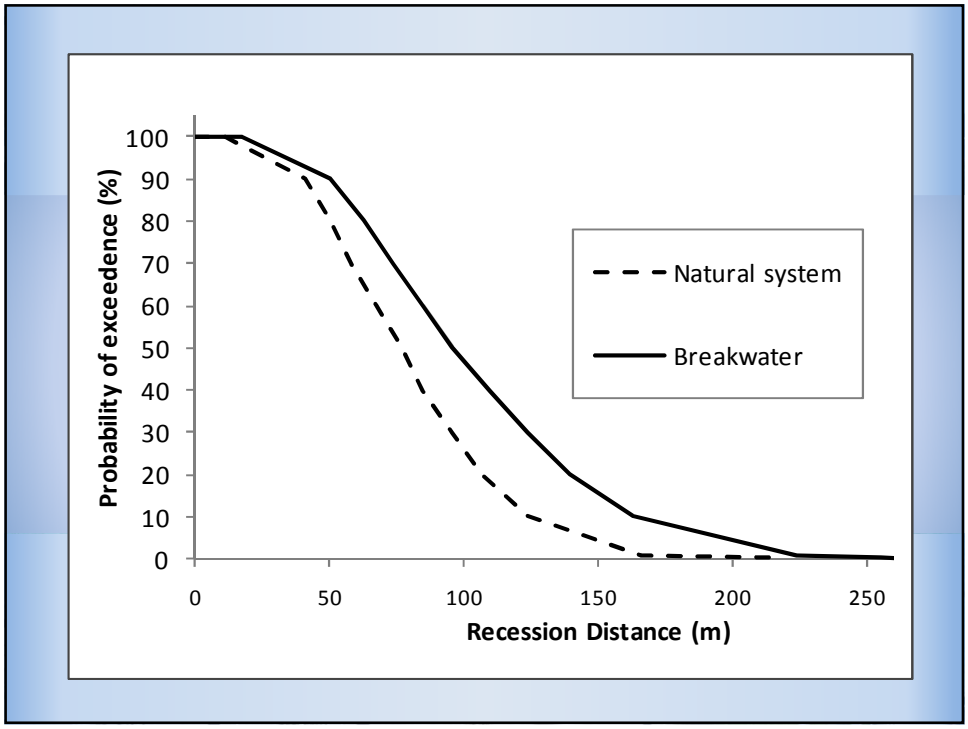
Year	Nourishment volume (m3)	Alongshore Extent (m)	m^3/m
1990	1,200,000	2,500	80
1997	250,000	2,200	114
1999	1,000,000	3,900	256
2000	96,400	2,500	39
2003	664,900	8,600	77
20			






Distance seawards from shoreline (m)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Elevation (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Surveyed
Calibrated
Stochastic model simulation - schema
repeat many times
P
sample
model
output
probabilities
for inputs
P
0.020
0.010
0.000
-50
0
50
100
150
output magnitude
(predictions)


Ostia
Coastal Recession Risk
Legend
Shoreline 2005
Contours:
% risk of exceedence
90%
50%
40%
30%
10%
1%
0.1%
N
Probability of exceedence (%)
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
Recession Distance (m)
0
70
140
280
420
560
Meters



Uncertainty analysis

Effects of breakwater

	Recession	Virtual recession (breakwater)		Actual effect
Risk rating	**Forecast**	**Forecast**	**Shoreline position (landwards of present)**	**Profile lowering seaward of breakwater**
2007 - actual	0 m	0 m	217 m ± 50	2.3 m
2100 - 50%	77 m	96 m	217 + 96 = 313 m	2.3 + 1.2 = 3.5
2100 - 10%	124 m	163 m	217 + 124 = 341 m	2.3 + 1.8 = 4.1
2100 - 1.0%	166 m	224m	217 + 224 = 441 m	2.3 + 2.3 = 4.6
2100 - 0.1%	216 m	255 m	217 + 255 = 472 m	2.3 + 2.5 = 4.8

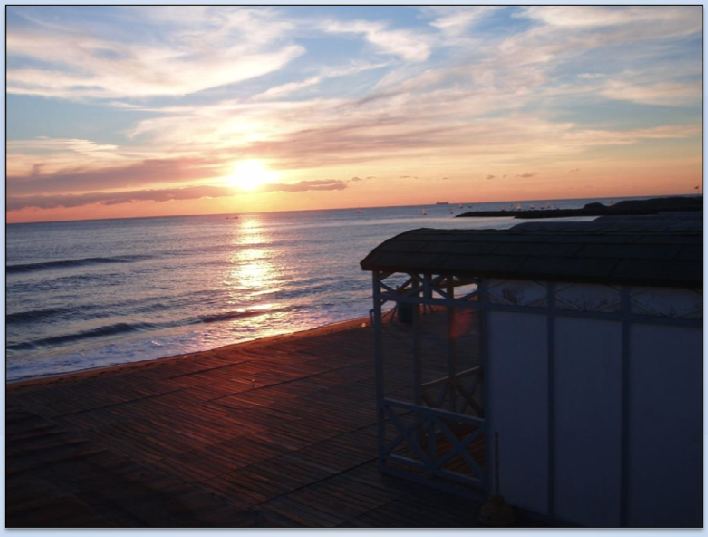
Uncertainty analysis

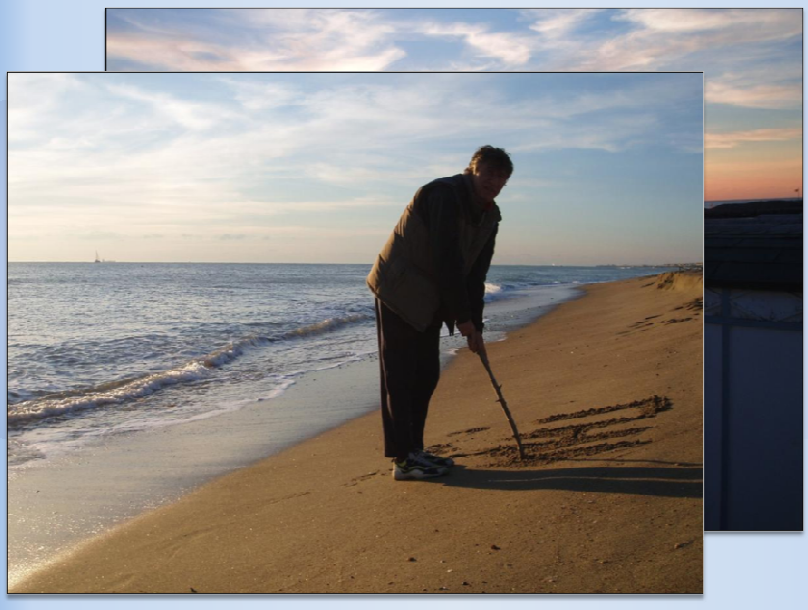
Sand nourishment

	Recession	Nourishment volumes		Cost	
Risk rating	**Forecast**	**Ostia total m^3**	**m^3 per year**	**Ostia total (€)**	**€ per year**
2007 - actual	**0 m**	**3,451,300**	**230,087**	**29,833,842**	**1,988,923**
2100 - 50%	77 m	7,663,279	82,401	64,601,441	694,639
2100 - 10%	124 m	12,499,490	134,403	105,370,701	1,133,018
2100 - 1.0%	166 m	16,821,211	180,873	141,802,806	1,524,761
2100 - 0.1%	216 m	21,966,116	236,195	185,174,359	1,991,122

Conclusions for 2100

- Chance of virtual recession due to sea level rise being greater than present - 0.1 %
- Chance of breakwater undermining due to sea level rise being greater than present – 1%
- Chance that sand nourishment rates required to compensate for sea level rise will be greater than present – 0.1 %
- Uncertainty about future shoreline adjustment to reduced sediment supply and the combined effects of management interventions





CLIMATE CHANGE VERSUS ANTHROPOGENIC EFFECTS ON UNCERTAINTY: TIBER DELTA EROSION

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References:

BELLOTTI, P., CHIOCCI, F. L., MILLI, S., TORTORA, P. & VALERI, P. (1994) Sequence stratigraphy and depositional setting of the Tiber Delta: integration of high-resolution seismics, well logs and archaeological data. Journal of Sedimentary Research, B64(3), 416-432.

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Parameter values

Triangular distribution:

- Shoreface geometry
- Sediment supply
- Sea kevek rise
- Lower shoreface response