USACE North Atlantic Coast Comprehensive Study: Natural and Natural-Based Approaches to Support Coastal Resilience and Risk Reduction

Working Meeting Washington DC November 21-22 2013

THE VENICE PROJECT

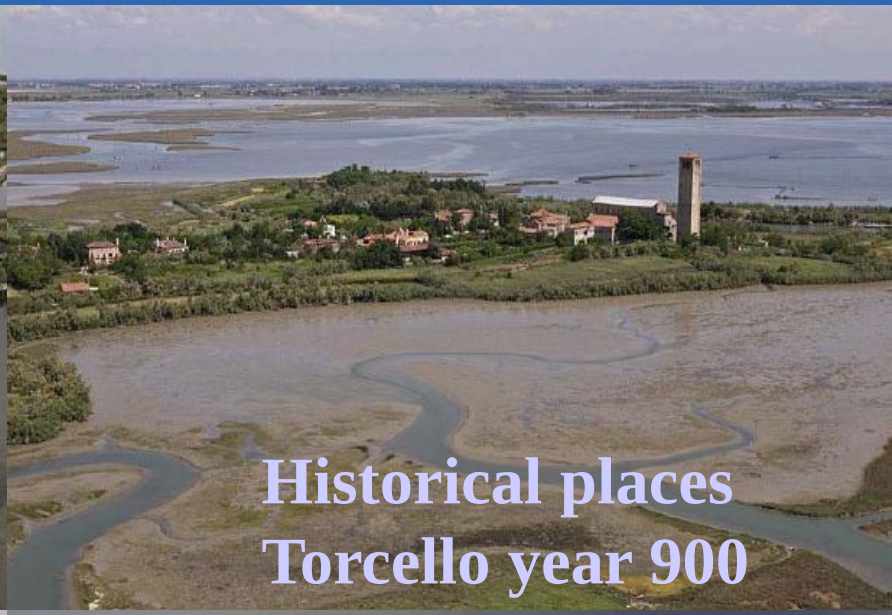
Building with Nature for Environmental Restoration and Resilient Storm Surge Protection

Hermes Redi, CEO Consorzio Venezia Nuova, CVN

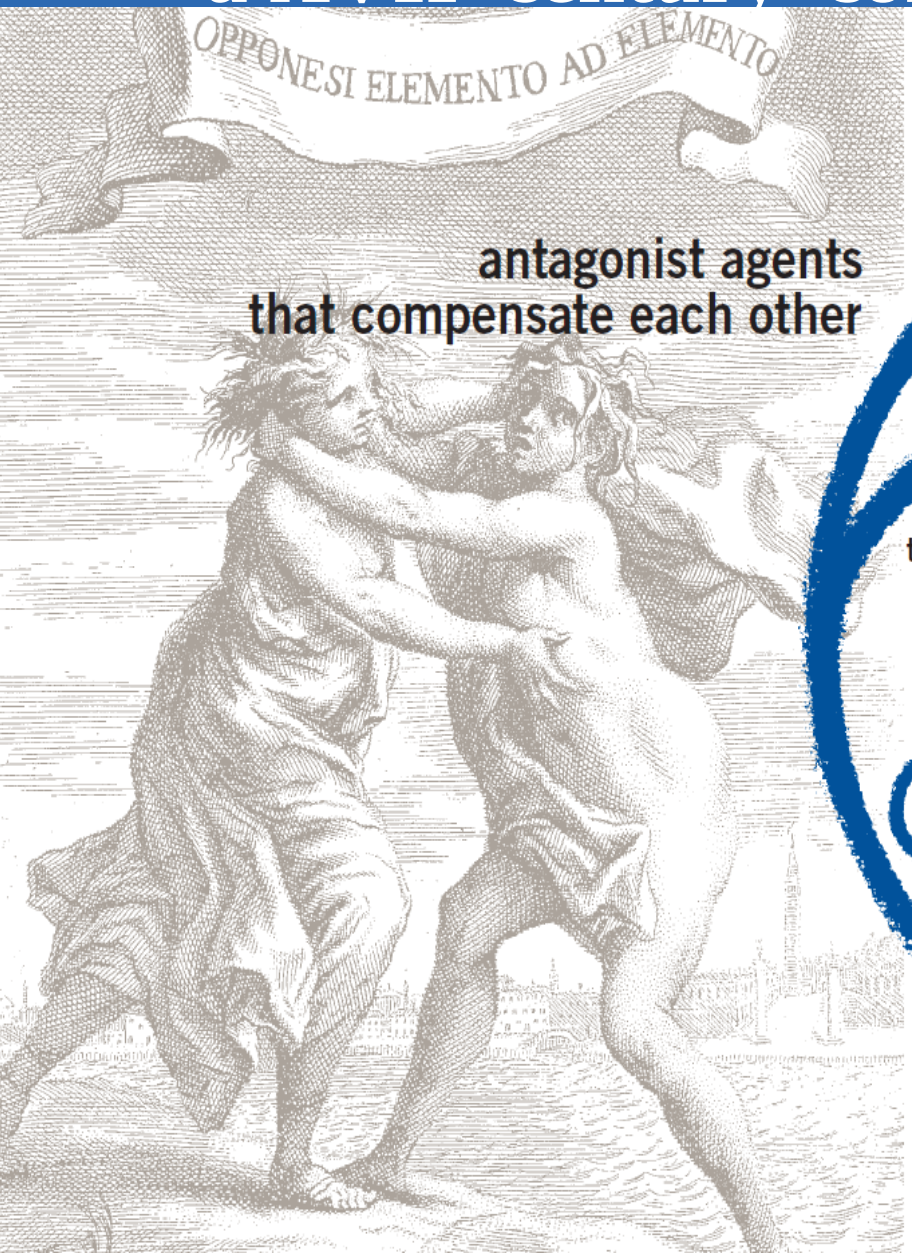
G. Cecconi, Dir. Information and Knowledge Management Centre, CVN

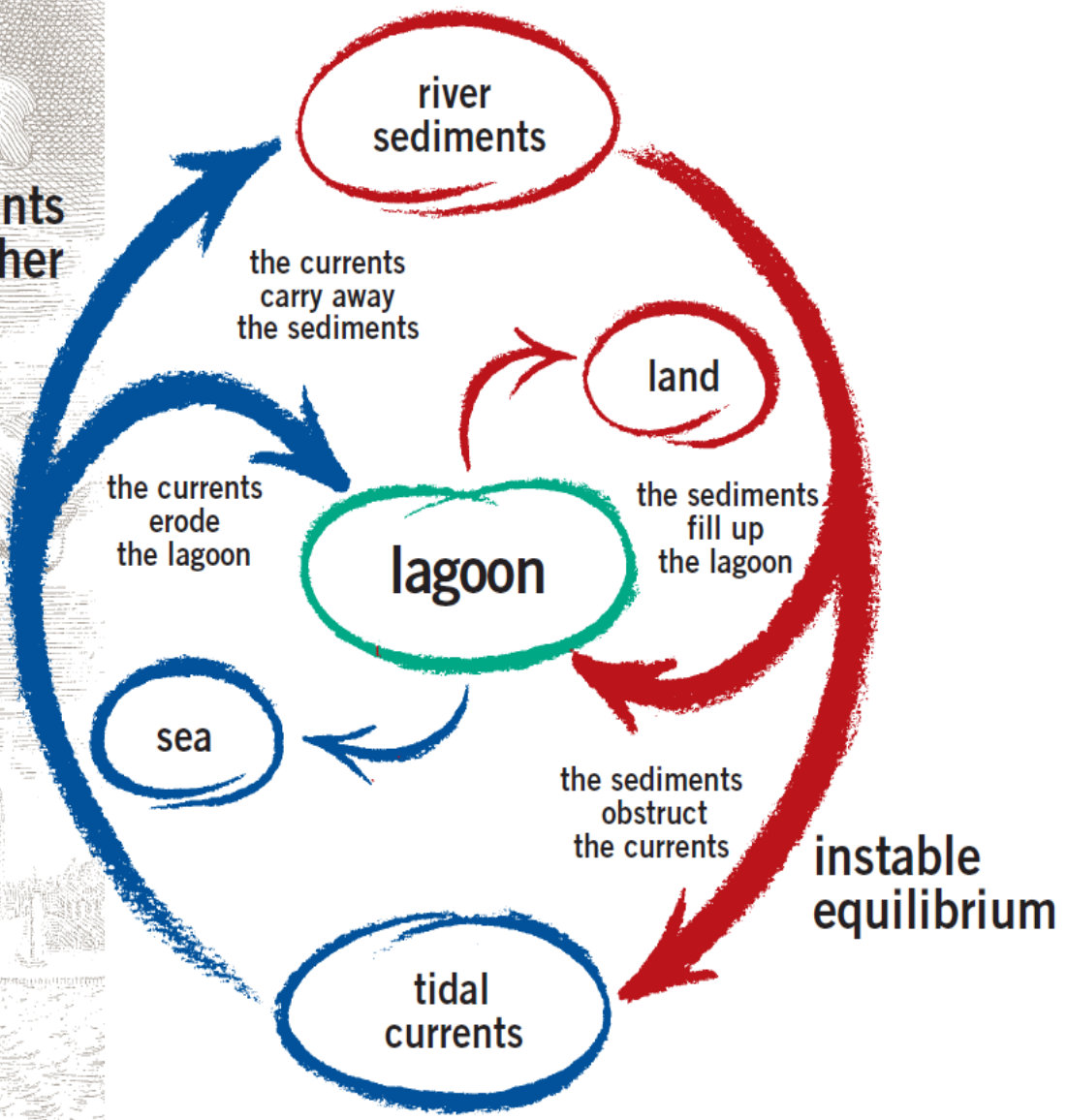
A complex system

A complex system



Land / Water interaction
a XVII century concept of co-evolution





The Venice lagoon risks

An integrated system of measures

Envinronmental recovery

Securing polluted sites, improvement of the water and sediment quality

Urban resilience

Raising of banks and pavements

Control and management

Studies, surveys, monitoring

Envinronmental Resilience

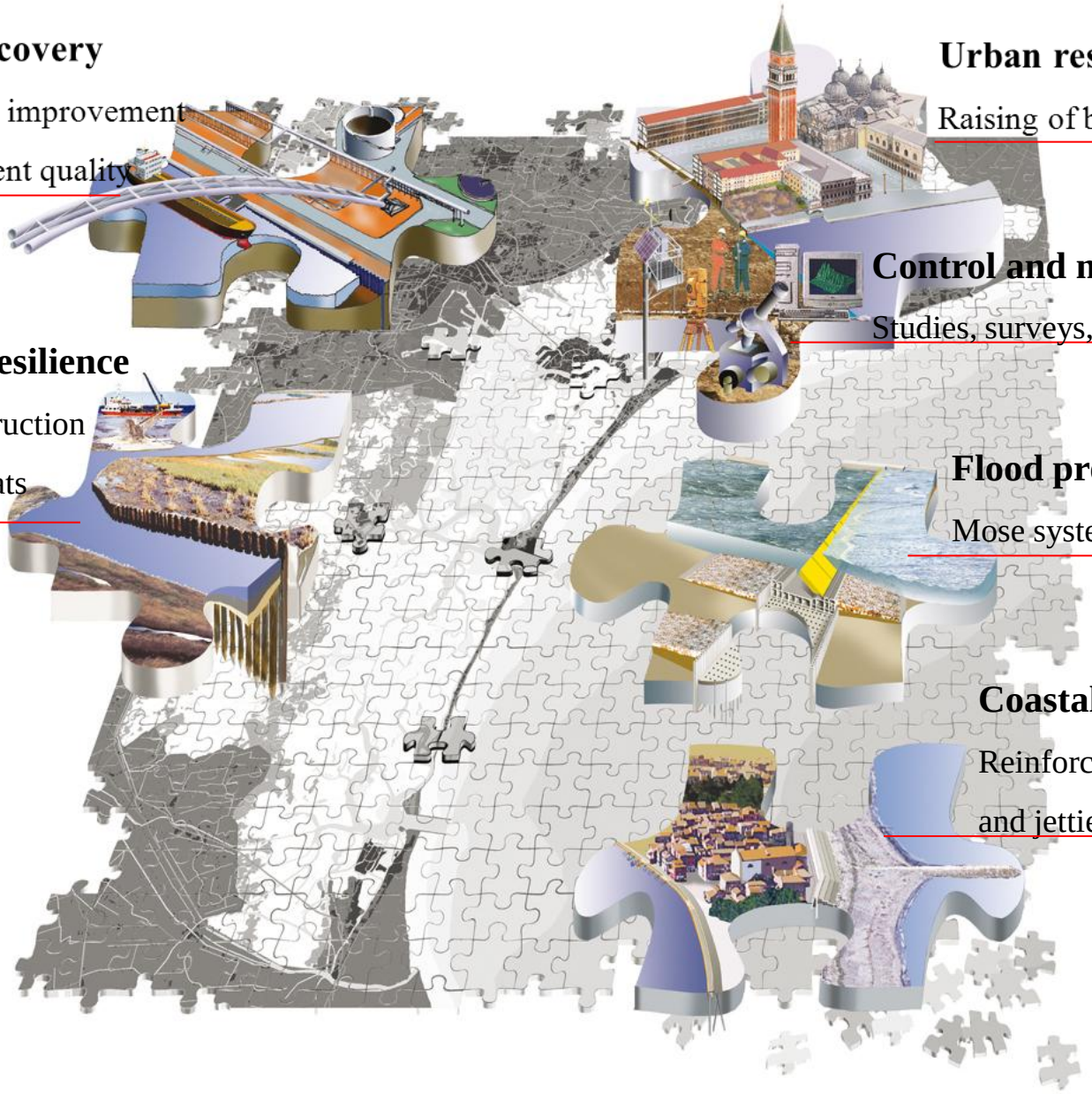
Protection and reconstruction of structures and habitats

Flood protection

Mose system

Coastal protection

Reinforcement of the littoral and jetties



Building with Nature: a beneficial interaction of structural measures and natural processes

From a foot-print to a salt-marsh

A Shelter Open to Natural Transport of Organic Matter and Solar Energy

Self-structuring communities: microbial mat biostabilization

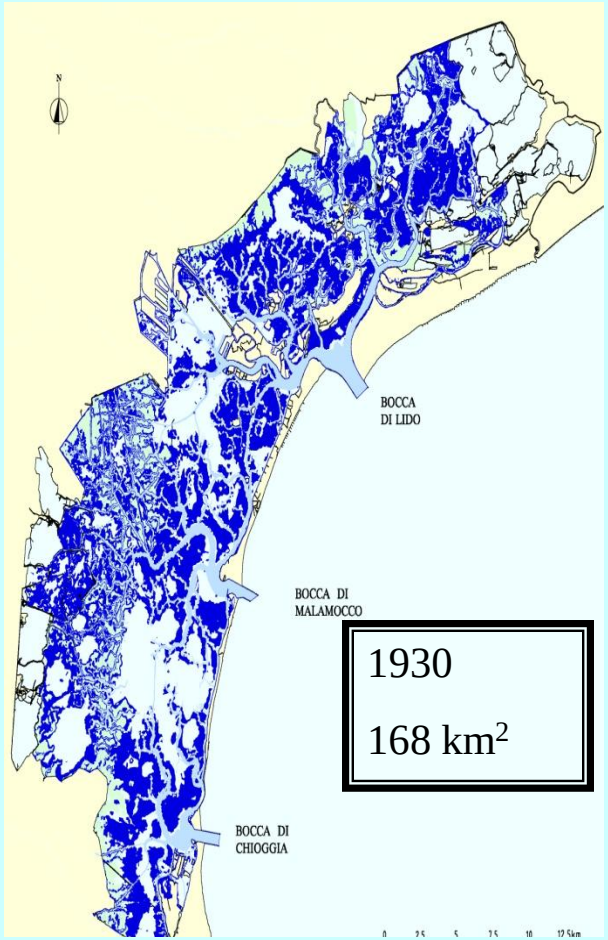
An evolving landscape :

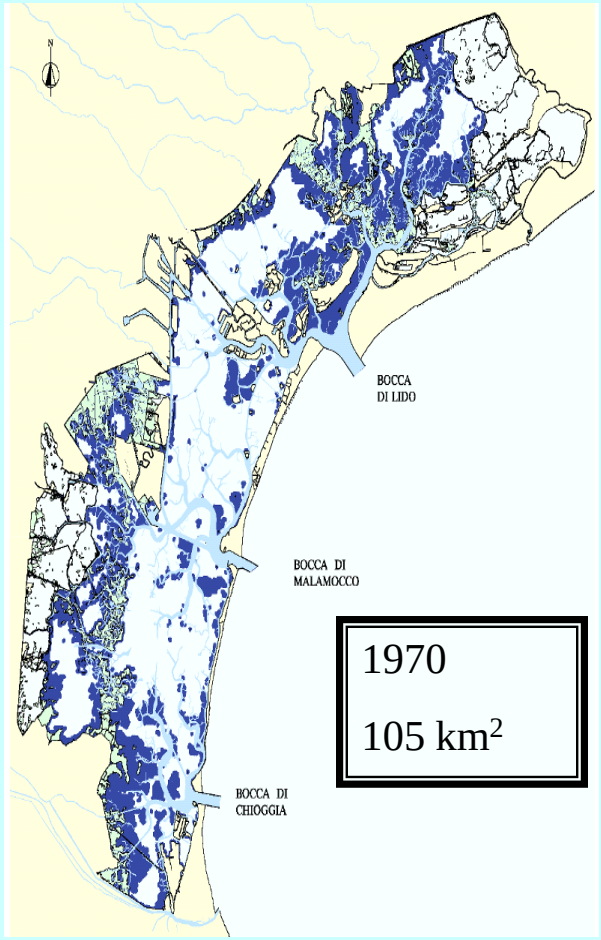
from 50 year old salt- marsh (on the right)
to 5 year old new shoals (on the left)

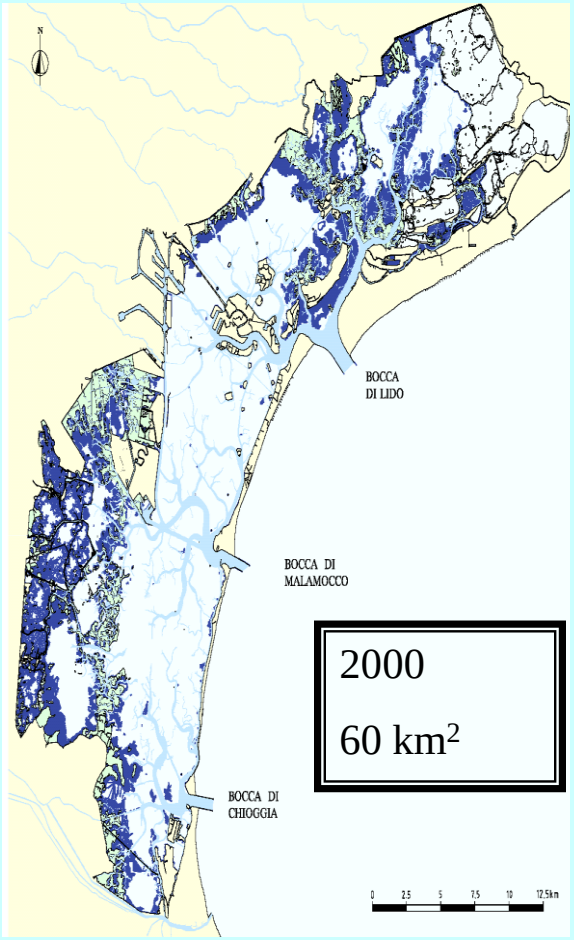
artificial landscape by compaction of sediment fills

Accretionary processes driven by protective measures: Geo-synthetic Gabions and Oyster reef

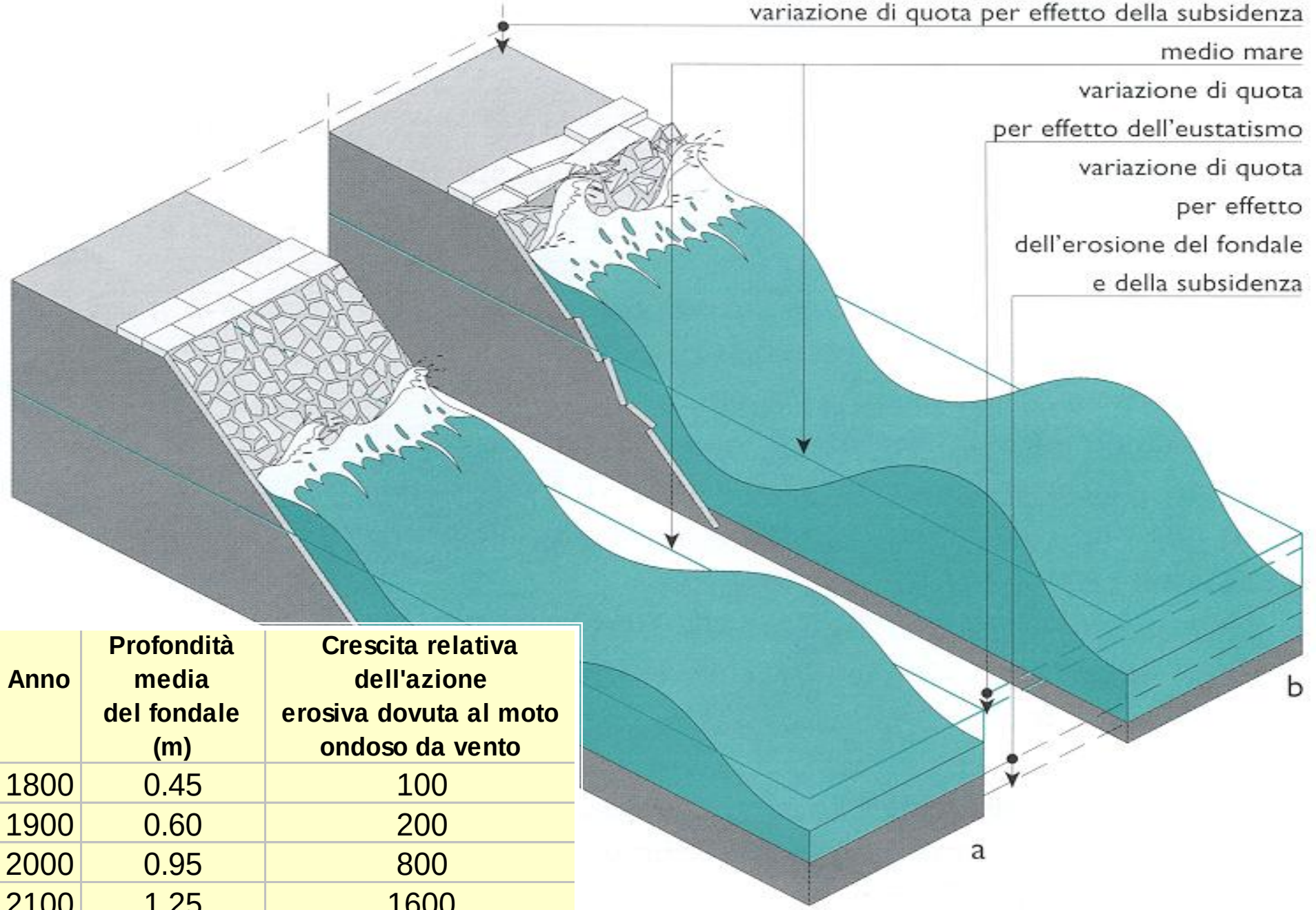
LOSS OF INTERTIDAL HABITAT DUE TO R.S.L.R







Exponetial damages on wave protections



Anno	Profondità media del fondale (m)	Crescita relativa dell'azione erosiva dovuta al moto ondoso da vento
1800	0.45	100
1900	0.60	200
2000	0.95	800
2100	1.25	1600

LOSS OF BENTIC COMMUNITIES

STATE OF REFERENCE

Low waves

Low depth (0.5 m b.s.l.)

Shoals

Low turbidity

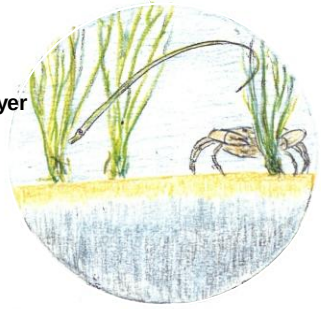
Calm waters

Deep channel

Abundance of eel – grass

and of benthic species

Oxidized layer



PRESENT STATE

High waves

High turbidity

Agitated waters

No shoals,

deepening and flattening

of the tidal flat (>1.0 m b.s.l.)

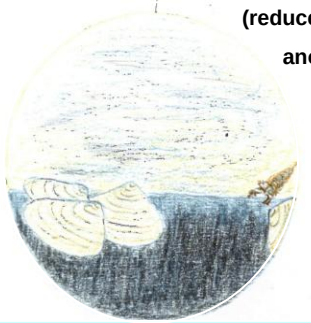
Siltation of channel

Sediment resuspension

Only opportunistic species

(reduced biodiversity) in

anoxic sediment



Re-use of dredged sediments in confined areas for constructed salt marsh habitat

During 26 years 1987-2013

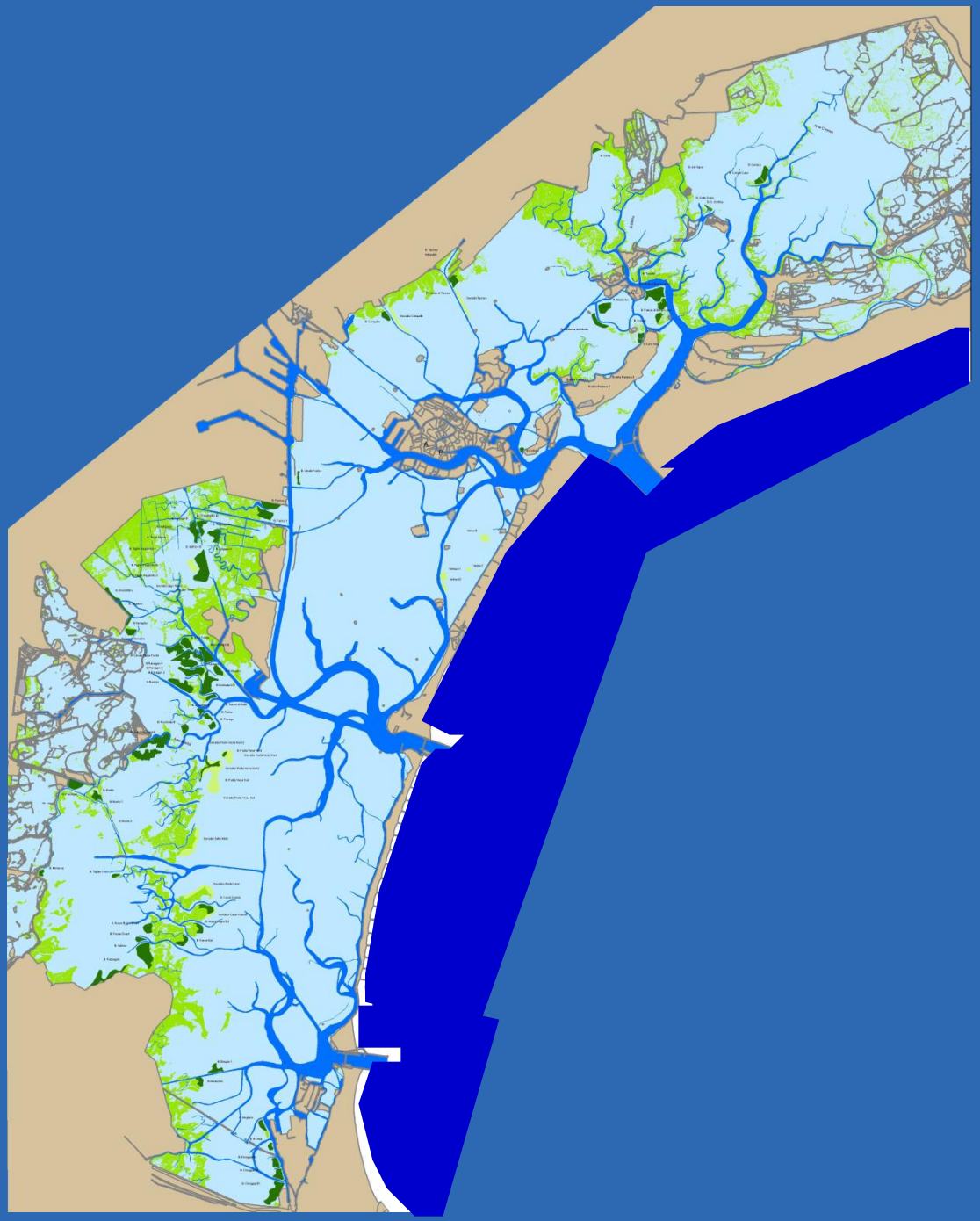
a volume of 20.000.000 m^3 of sediment

from maint. dredging

has been re-used on 15 km^2

for building 106 salt marshes

and 18 tidal flats



Evolution stages of constructed salt marshes

Stadio 0

< 2 Months

Mean elevation of surface a.s.l.

Flooding time <3%

+0.70 – 1.00 m a.s.l.

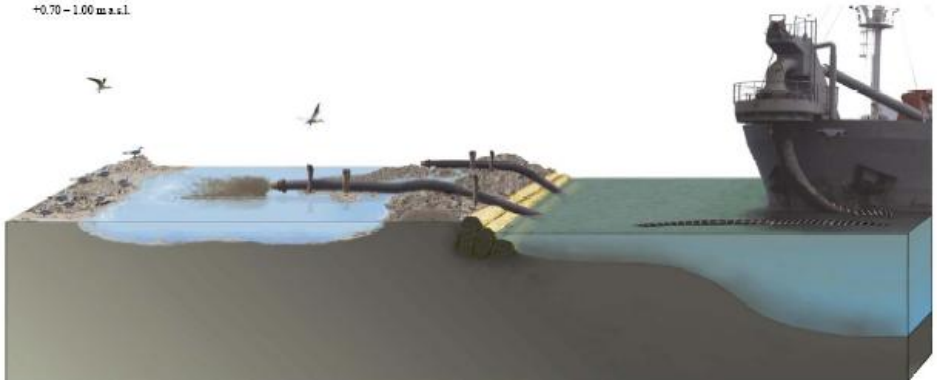
Vegetation

absent

Birds

Ponds and tidal creeks

absent



Stadio 1

< 1 year

Mean elevation of surface a.s.l.

Flooding time 3-25%

+0.40 – 0.70 m a.s.l.

Vegetation

Birds

Ponds and tidal creeks

absent

Stadio 3

3-5 years

Mean elevation of surface a.s.l.

Flooding time 20-55%

+0.20 – 0.50 m a.s.l.

Vegetation

Birds

Ponds and tidal creeks

Stadio 4

>5 years

Mean elevation of surface a.s.l.

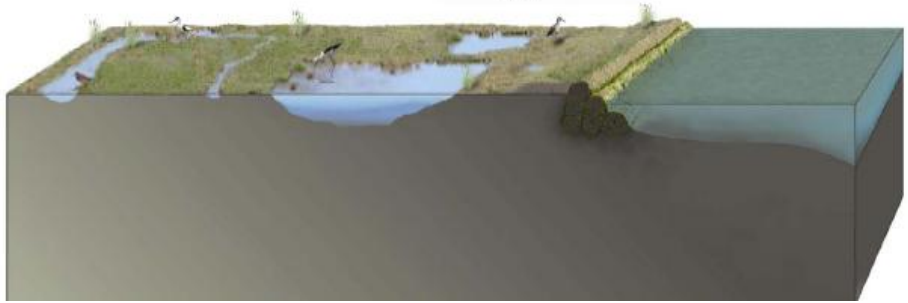
Flooding time 30-55%

+0.20 – 0.40 m a.s.l.

Vegetation

Birds

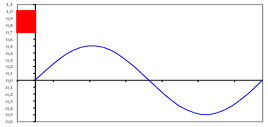
Ponds and tidal creeks



Stadio 0

< 2 Months

Mean elevation of surface a.s.l.



Vegetation

absent

Birds

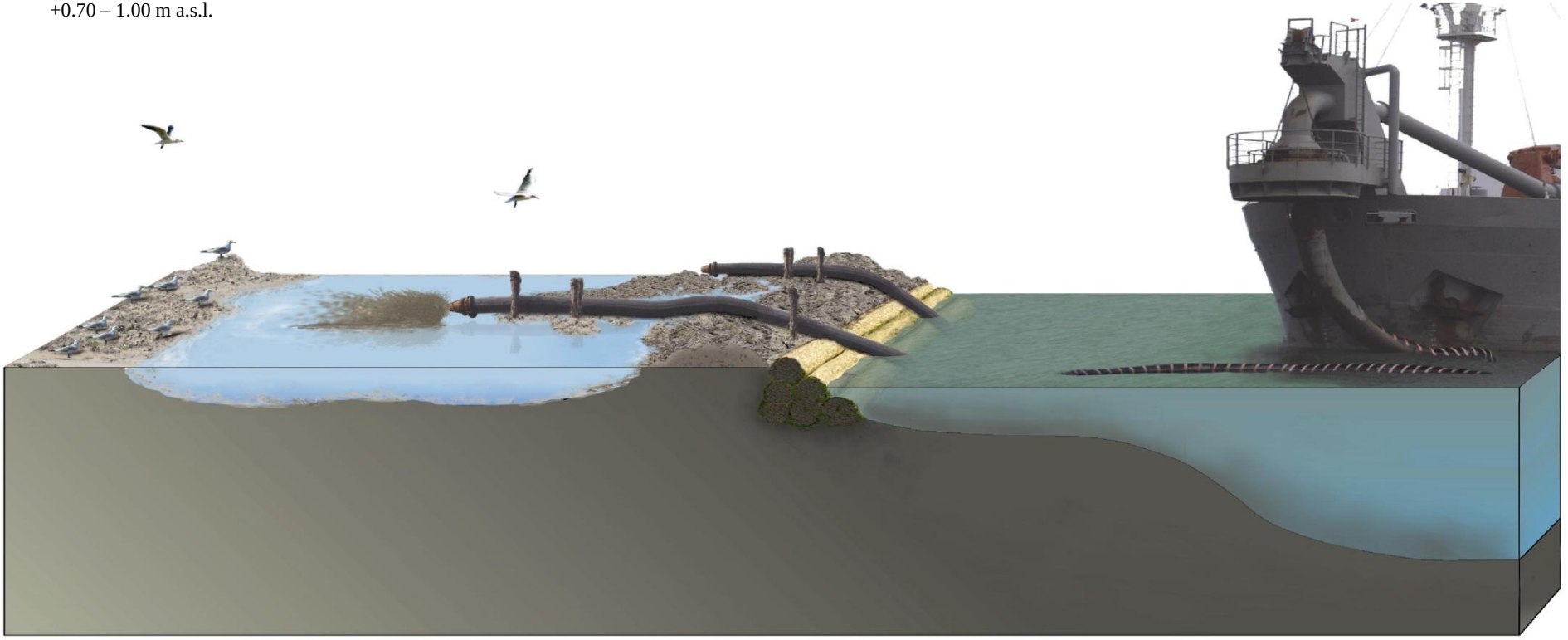
Gabbiano reale (*Larus michahellis*)

Ponds and tidal creeks

absent

Flooding time <3%

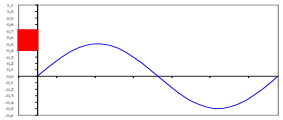
+0.70 – 1.00 m a.s.l.



Stadio 1

< 1 year

Mean elevation of surface a.s.l.



Flooding time 3-25%

+0.40 – 0.70 m a.s.l.

Vegetation

Salicornieto

Birds

Gabbiano reale (*Larus michahellis*)

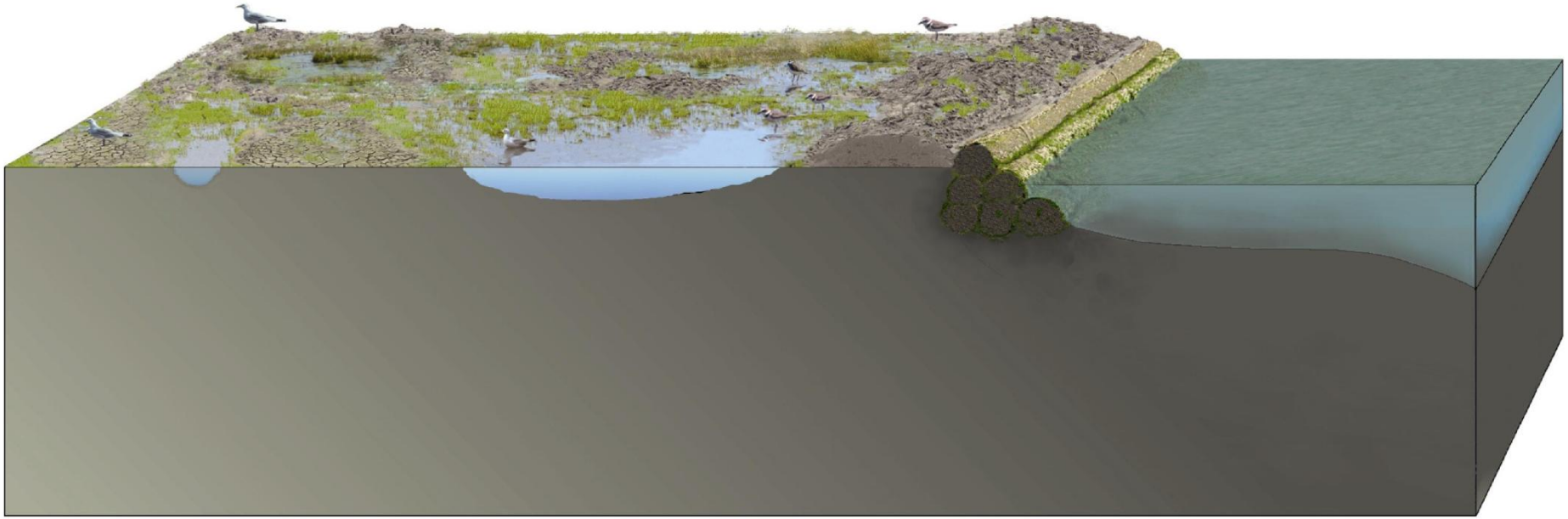
Fratino (*Charadrius alexandrinus*)

Beccaccia di mare (*Haematopus ostralegus*)

Fraticello (*Sterna albifrons*)

Ponds and tidal creeks

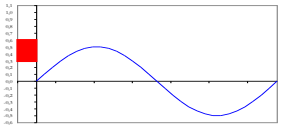
absent



Stadio 2

1-3 years

Mean elevation of surface a.s.l.



Flooding time 8-40%

+0.30 – 0.60 m a.s.l.

Vegetation

Salicornieto

Sarcocornieto

Birds

Gabbiano reale (*Larus michahellis*)

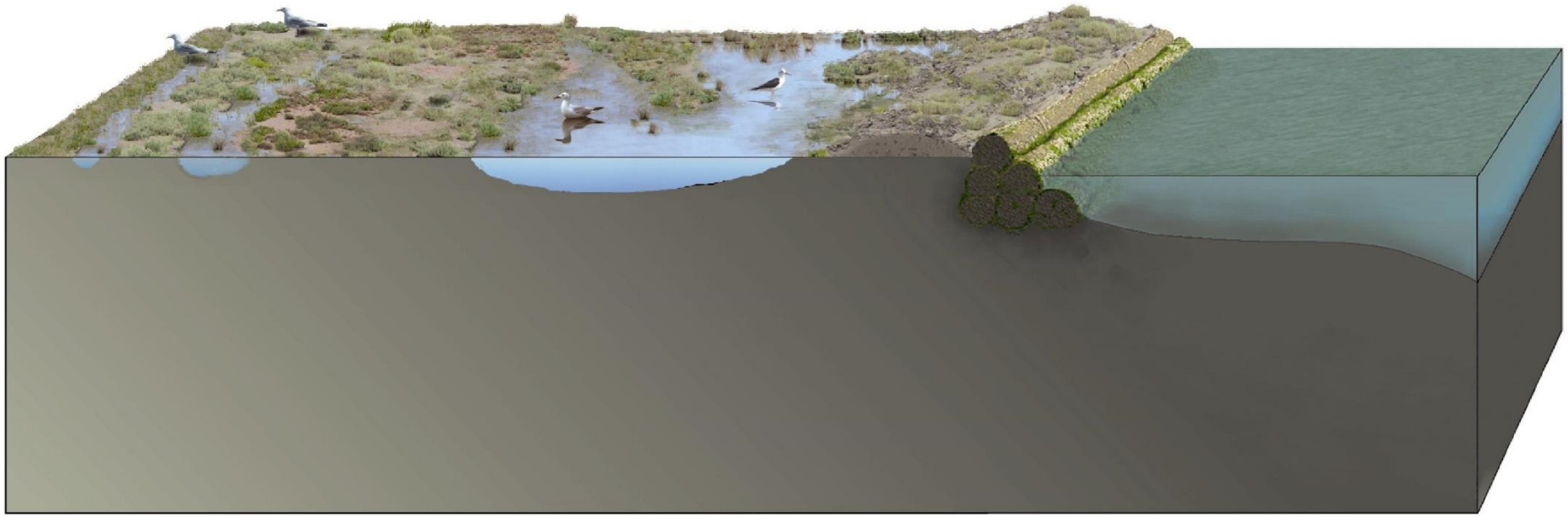
Fratino (*Charadrius alexandrinus*)

Beccaccia di mare (*Haematopus ostralegus*)

Fraticello (*Sterna albifrons*)

Ponds and tidal creeks

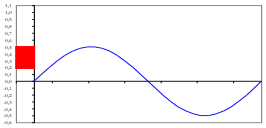
Rete di ghebi e chiari ben distinguibile



Stadio 3

3-5 years

Mean elevation of surface a.s.l.



Flooding time 20-55%

+0.20 – 0.50 m a.s.l.

Vegetation

Sarcocornieto

Limonieto

Aggregazione ad *Halimione portulacoides* e aggruppamen a *Suaeda maritima*

Birds

Gabbiano reale (*Larus michahellis*)

Pettegola (*Tringa totamus*)

Volpoca (*Tadorna tadorna*)

Germano reale (*Anas platyrynchos*)

Cavaliere d'Italia (*Haematopus haematopus*)

Fratino (*Charadrius alexandrinus*)

Avocetta (*Recurvirostra avosetta*)

Beccaccia di mare (Haematopus ostralegus)

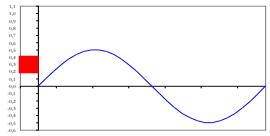
Ponds and tidal creeks

Rete di ghebi e chiari ben distinguibile

Stadio 4

>5 years

Mean elevation of surface a.s.l.



Flooding time 30-55%

+0.20 – 0.40 m a.s.l.

Vegetation

Sarcocornieto

Limonieto

Aggregazione ad *Halimione portulacoides* e aggruppamenti a *Suaeda maritima*

Birds

Gabbiano reale (*Larus michahellis*)

Pettegola (*Tringa totamus*)

Beccaccia di mare (Haematopus ostralegus)

Germano reale (*Anas platyrynchos*)

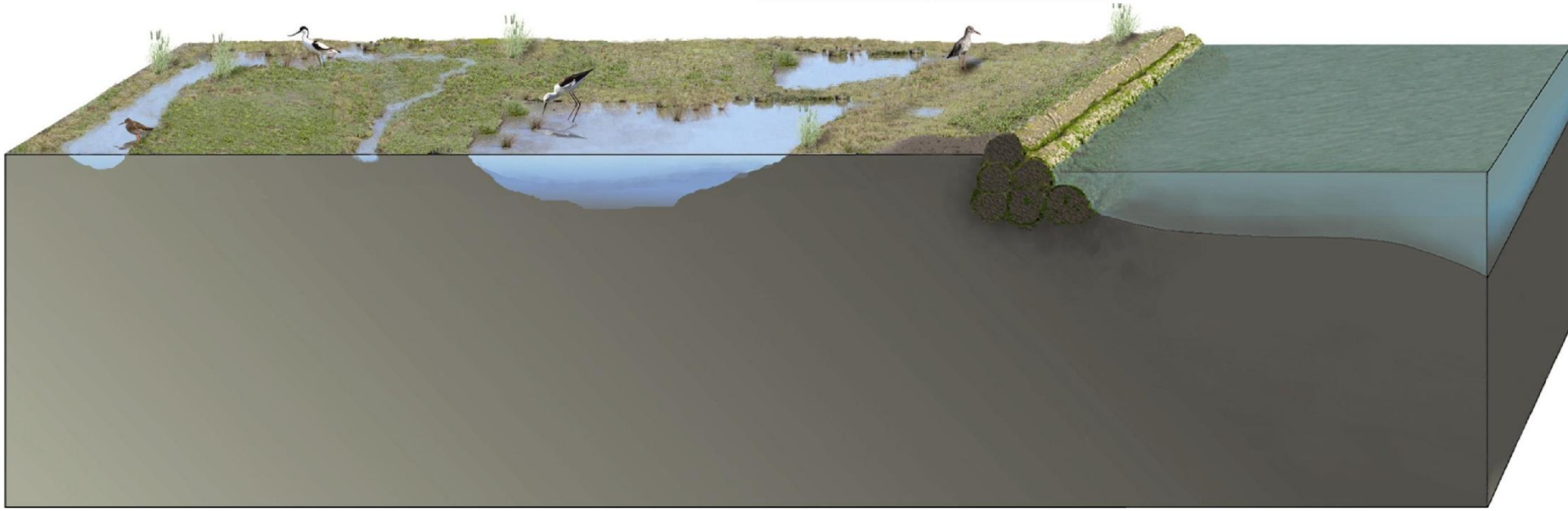
Cavaliere d'Italia (*Haematopus haematopus*)

Fratino (*Charadrius alexandrinus*)

Avocetta (*Recurvirostra avosetta*)

Ponds and tidal creeks

Superficie ad acqua pari al 20% del totale e rete ben sviluppata di ghebi e chiari



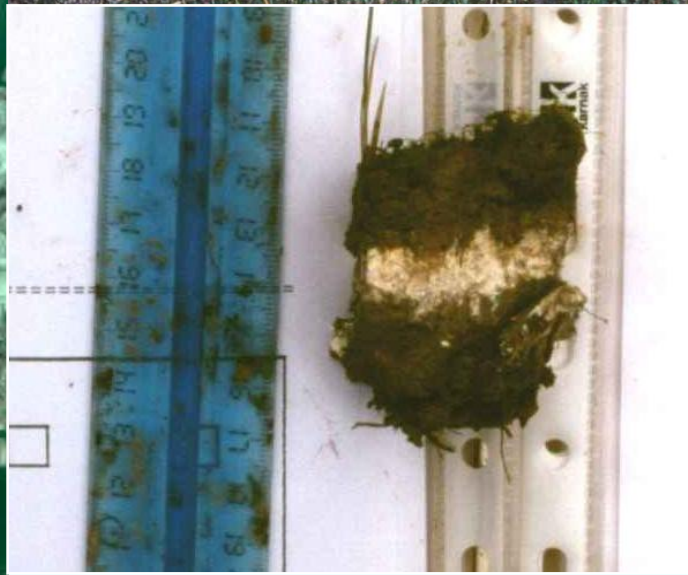
6 months: Compaction

2-3 years: Colonization

5 years: Natural adaptation to sea level rise

ADAPTATION TO RSLR

0.5 cm/year ACCRETION ON CONSTRUCTED SALT MARSHES



Constructed salt-marsh habitats

Endangered Breeding Species at Constructed Salt-Marshes (years 2005-2006)

Avocet (39-44 pairs)

Redshank (94-136)

Black-winged Stilt (96-69)

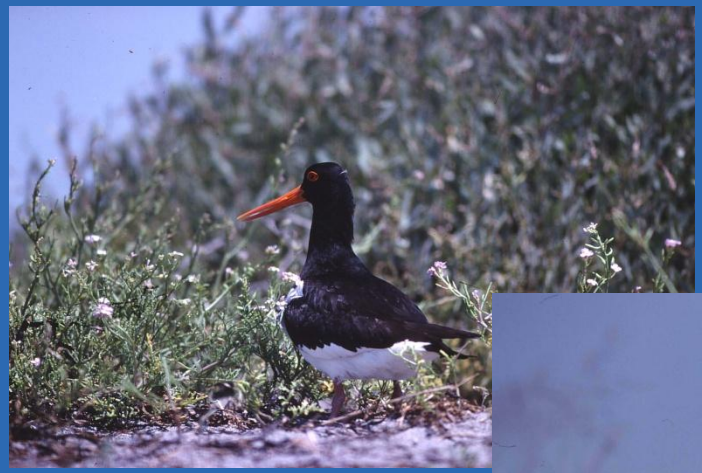
Kentish Plover (34-71)

Oystercatcher (31-38)

Shelduck (12-17)

Little Tern (115-205)

Yellow-legged Gull (553-1057)



AGE (YEARS)

ENVIRONMENTAL VALUE OF CONSTRUCTED SALT MARSHES:

Green: in line with expectations;

Orange: naturalization work required

Red: change in elevation required

16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

IN CORSO

Colmata D/E3
Colmata DE 2
ChioggiaB3
ChioggiaB2
ChioggiaB1
Colmata B4
Tezze Fonde
Campalto
Canal Grande
Fossei Est
Tagliae Sud
Acque Negre Ovest
Fossei Ovest
Dereganì
Canale Tessera
Romea
Vallona 2
Canale Serraglia
Morosina
Ravaggio 1
Pierimpiè
Lago dei Teneri 2
Lago dei Teneri 1
Cona
Bondantino
Stradoni
Serraglia
Laghi
Fusina 1
Burano
Mazzorbo
Novisso
Madonna del Monte
Fusina 2
Cenesa
Palude Burano Nord
Ca la Vela
Canale Capo
Palude Burano sud
Ravaggio 2
Ravaggio3
Certosa
Vallona 1
Novissimo
Alleghero
Ravaggio 4
Torson di Sotto
Buello
Buello1
Buello2
Pezzegalo
S. Erasmo
Volpego
TraghettoB
Torcello
TraghettoA
S.Cristina
Crevan
Del Vigno
Punta vecia Nord
Punta veciaSud
Casone Zappa A
Canale Fusina
Otregan 1
Canale Tezze Fonde
Remiera 3
Casone Zappa B
Selte soleri
Barena Cornio 1
Barena Cornio 2
Barena Cornio 3
Barena Cornio 4
Barena Marani F
Barena OTREGAN 2
Barena Tessera 1
Barena Tessera 2

Protected beach nourishment

Pellestrina barrier island

14 year after nourishment

Sediment fence dune management

Bio-structuring habitats are the result of primary production acting on designed partially confined areas open to the natural flow of sediments and solar energy

- Fresh-water wetlands at river outlets

- Salt- Marshes

- Dunes (*Ammophila littoralis)*

- Shoals of microbial mats

- Tidal flat vegetation (*eel-grass*)

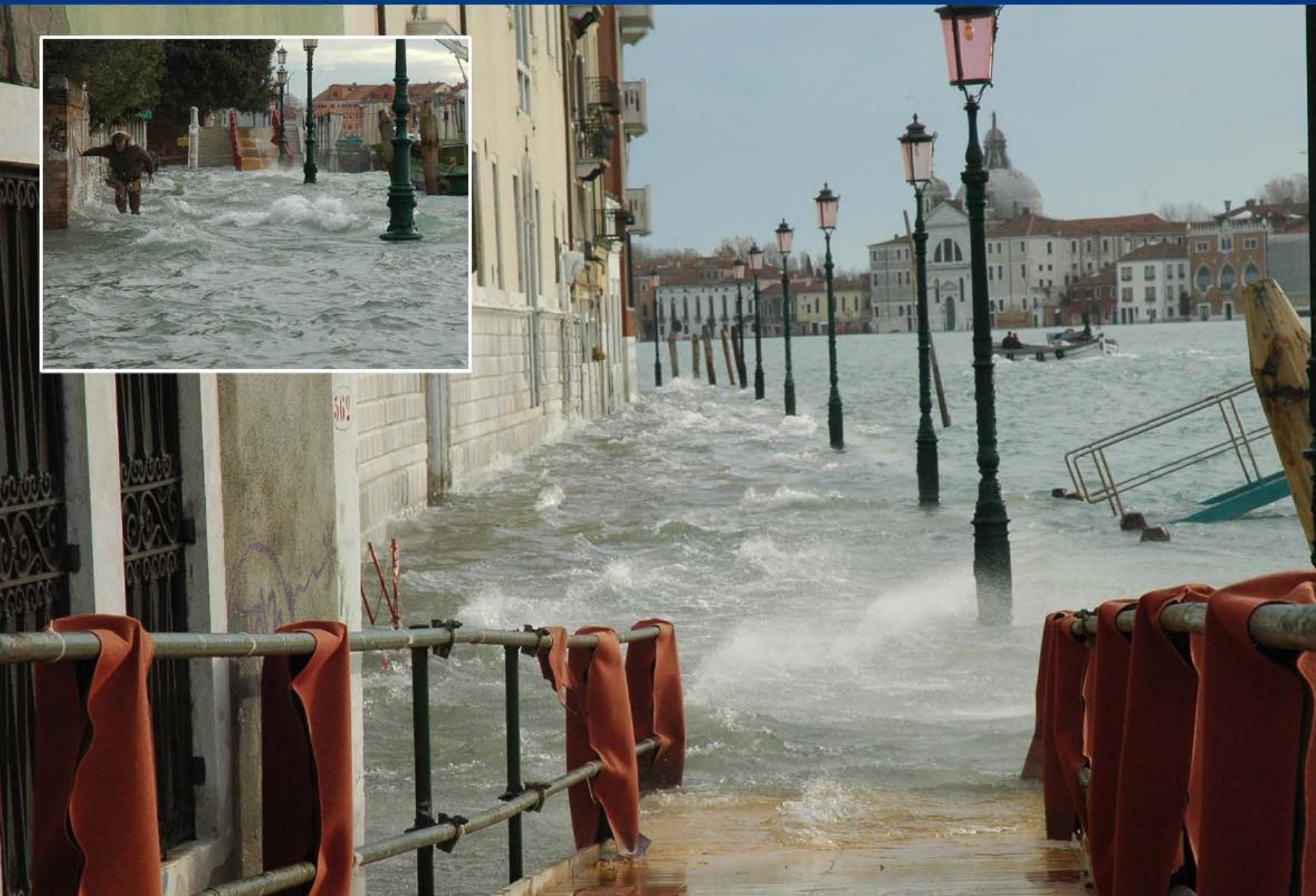
- Oyster reefs

Benefits/Processes of Bio-Structuring Habitats

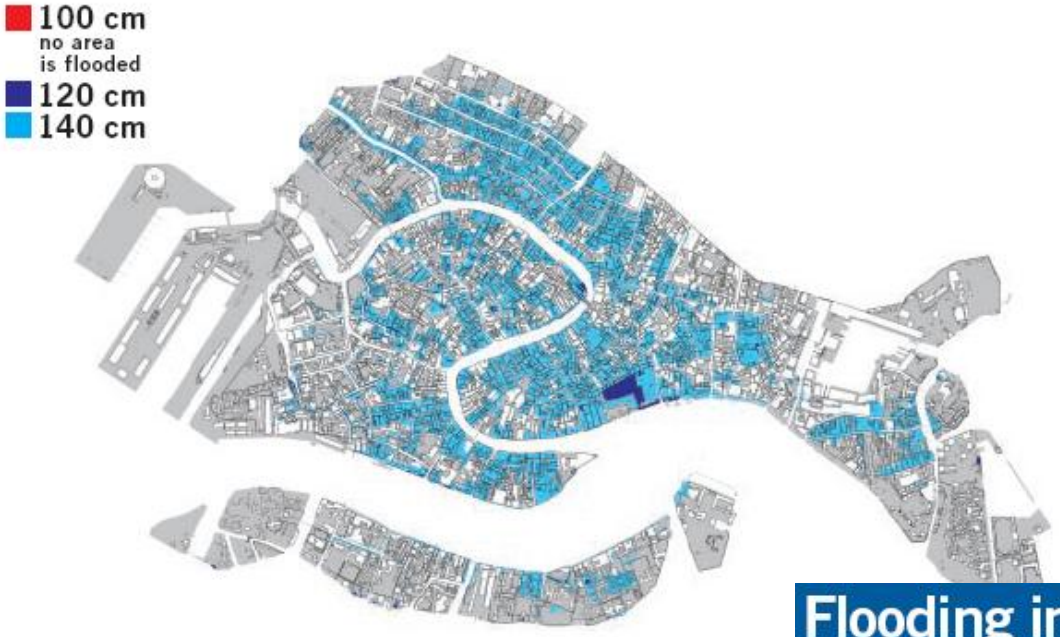
- **Protection from wave erosion and littoral overtopping**
- **Wetland adaptation to Relative Sea Level Rise**
- **Wetland sequestration of sediments, pollutants, and CO2**
- **Conservation of landscape, biodiversity and species of economical interest (fishes, birds)**

Flooding

Venice. December 1, 2008

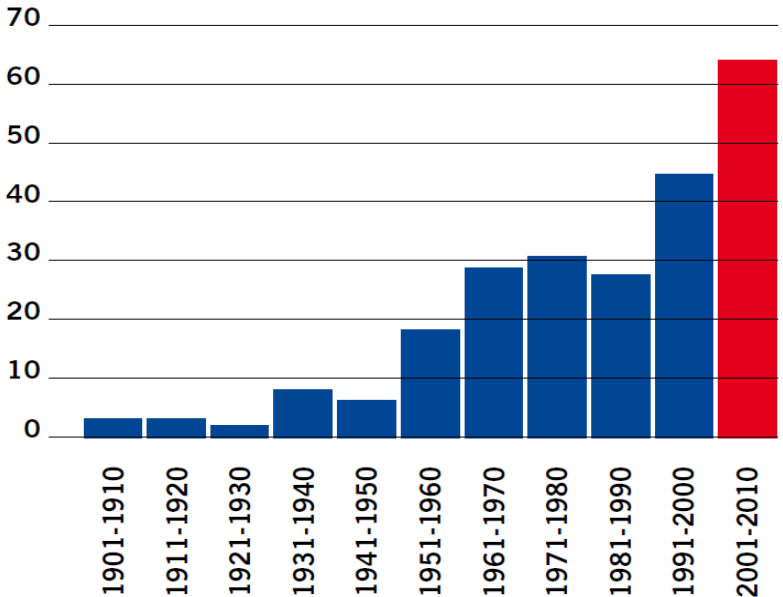


Flooding in Venice at the turn of the 20th century



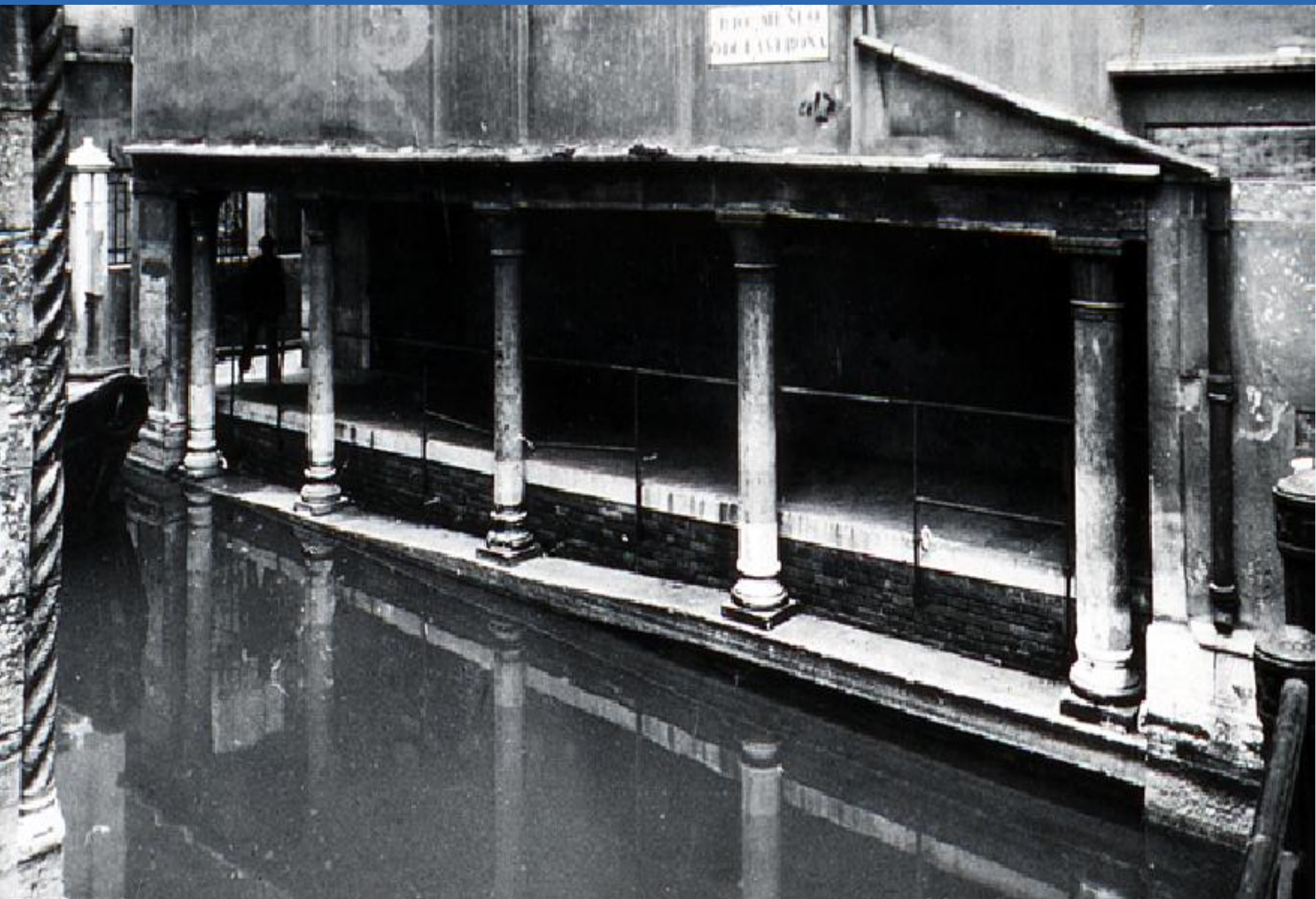
4	**Nov 1966**	**194 cm**
22	Dec 1979	166
1	Feb 1986	159
1	Dec 2008	156
12	Nov 1951	151
11	Nov 2012	149
16	Nov 2002	147
16	Apr 1936	147
25	Dec 2009	145
15	Oct 1960	145
24	Dec 2010	144
23	Dec 2009	144
6	Nov 2000	144
3	Nov 1968	144
1	Nov 2012	143

Increase in the frequency of floods events in Venice between 1901 and 2010

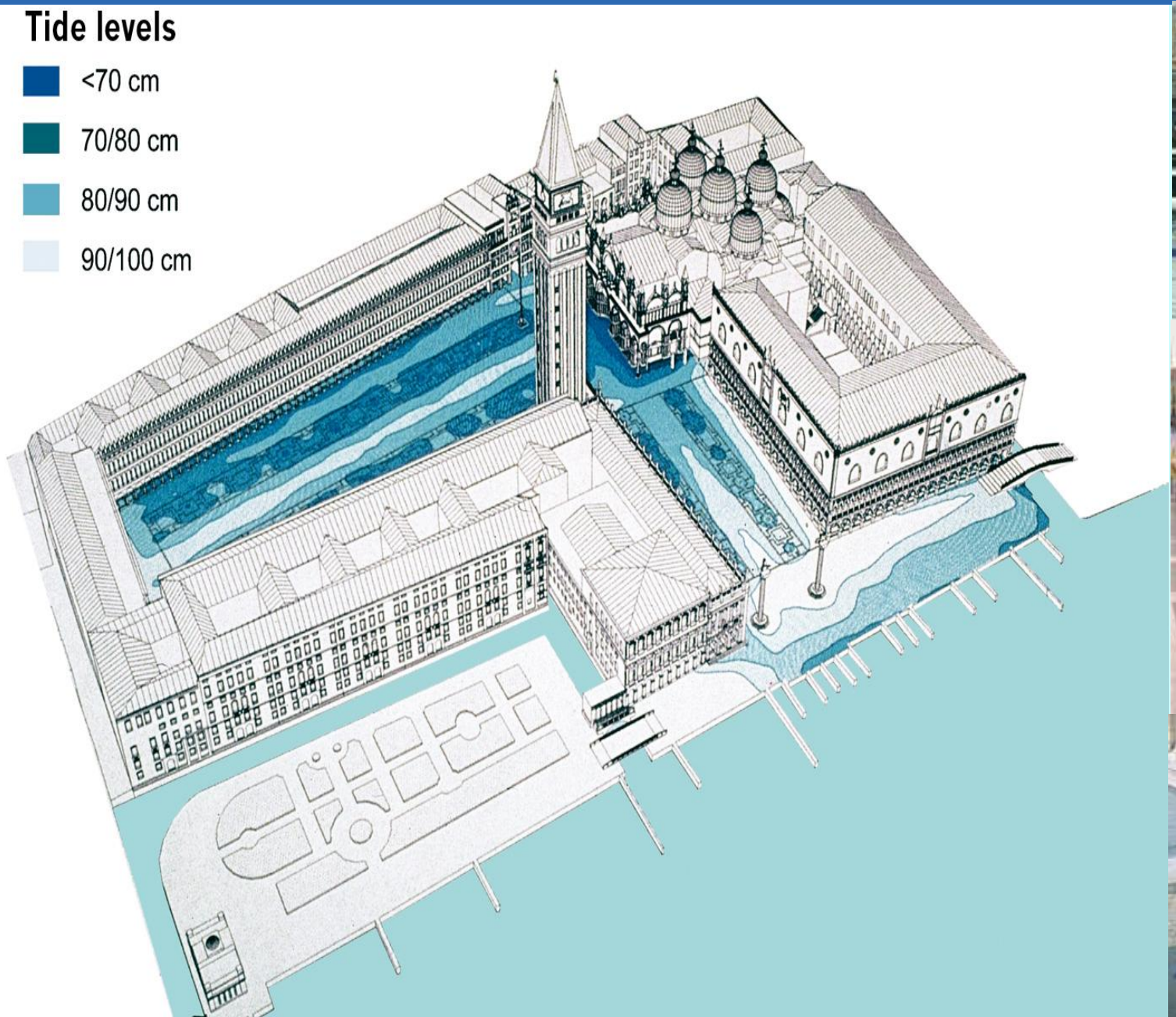


Flooding in Venice today

Urban Adaptation



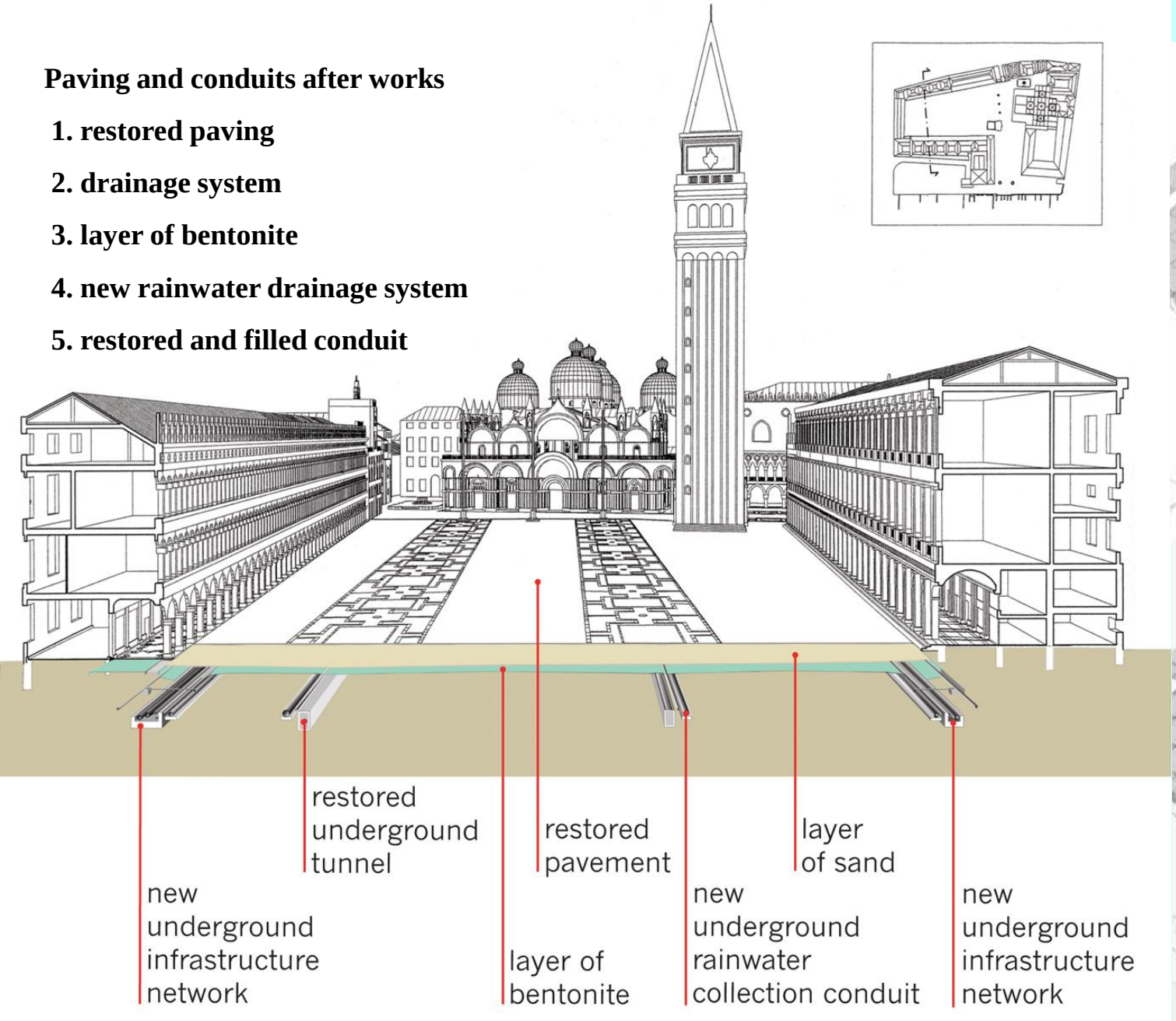
Piazza San Marco - vulnerability

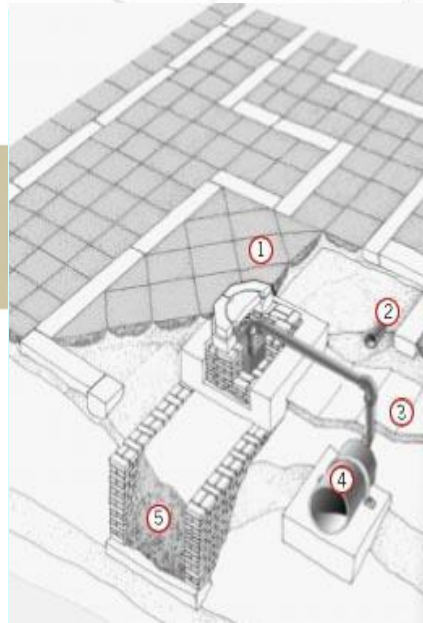


Piazza San Marco – the solution

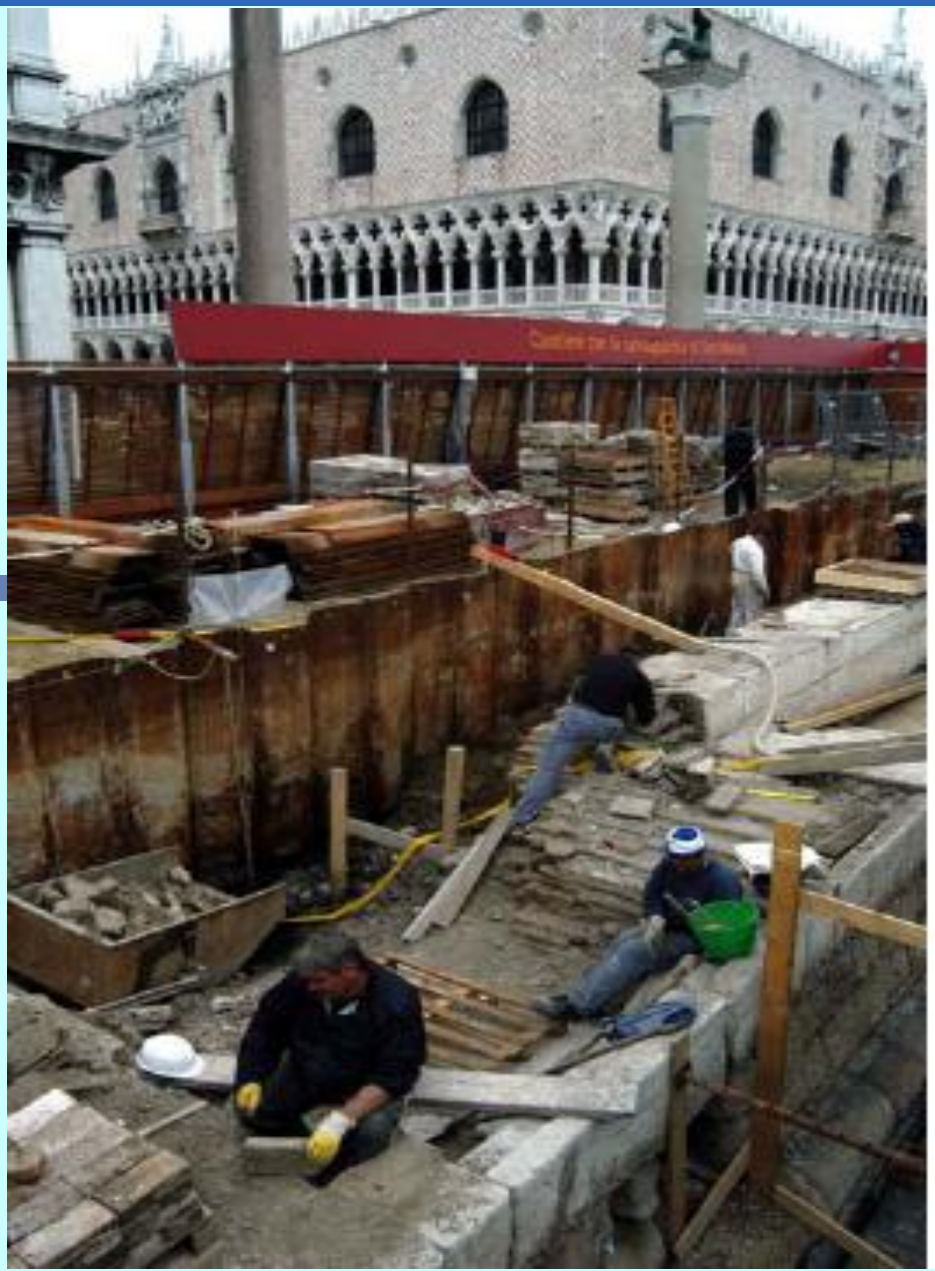
Paving and conduits after works

1. **restored paving**
2. **drainage system**
3. **layer of bentonite**
4. **new rainwater drainage system**
5. **restored and filled conduit**





Piazza San Marco – the solution

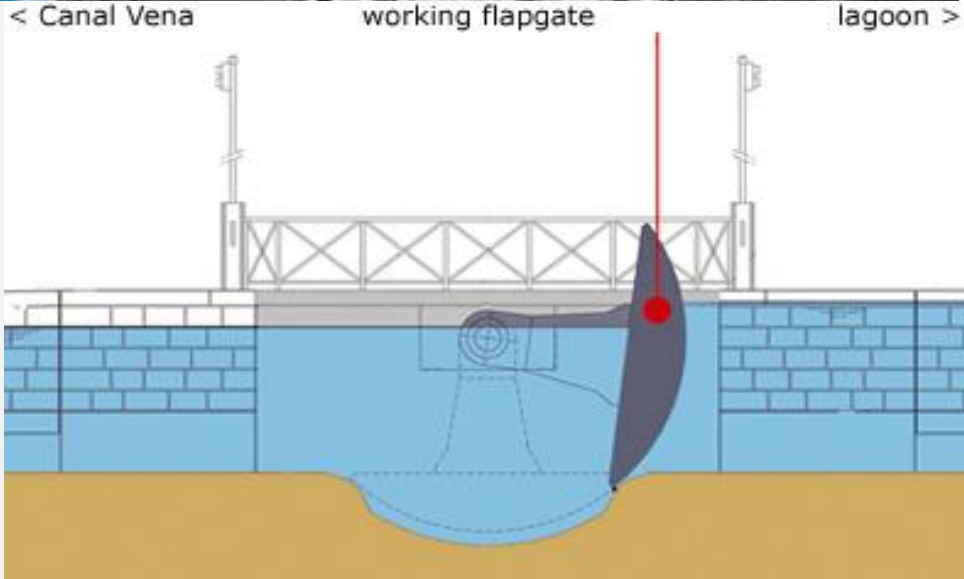


Venice, Tolentini area. The solution

Before

After
Raising of banks and pavements

Chioggia city - baby mose



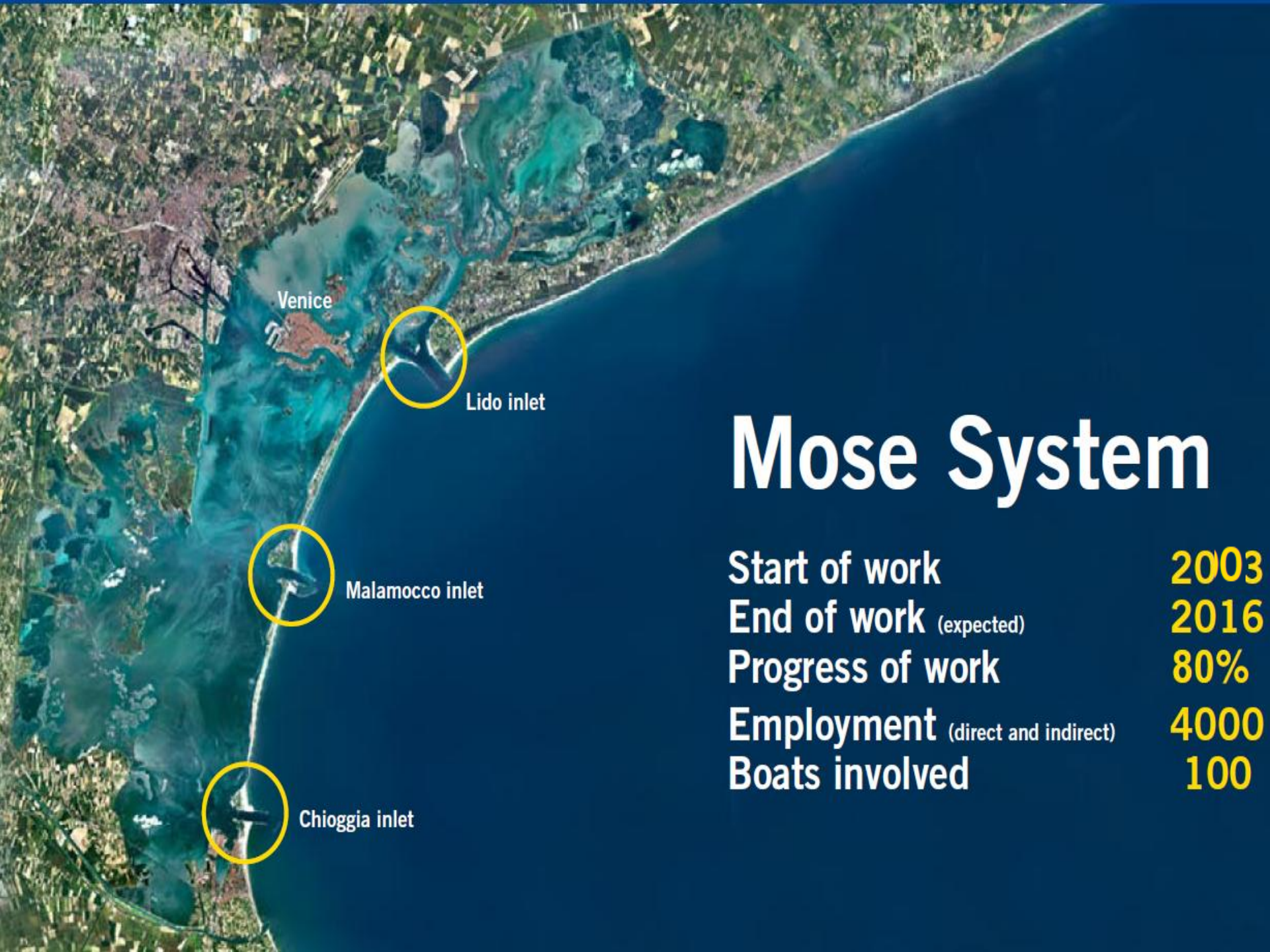
THE VENICE SOLUTION OF *BUILDING WITH NATURE*

RE-USE OF DREDGED SEDIMENTS

PROTECTED BEACH NOURISHMENT

URBAN ADAPTATION

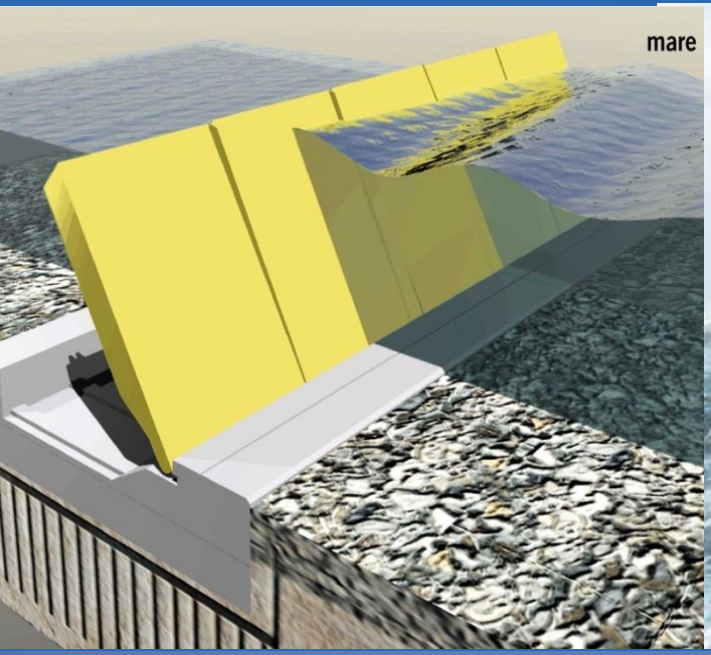
STORM SURGE BARRIERS AT LAGOON INLETS



Mose System

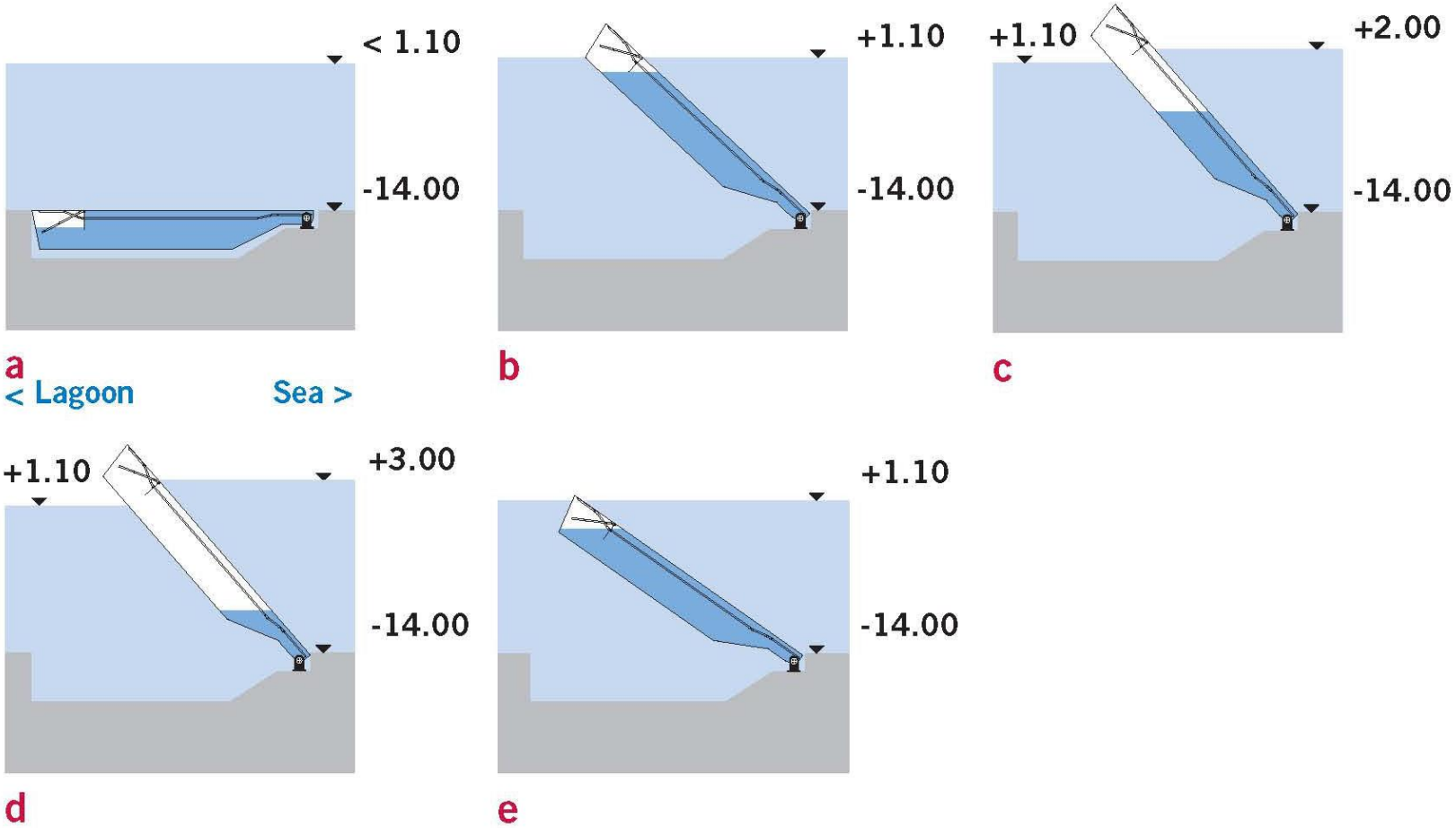
Start of work	2003
End of work (expected)	2016
Progress of work	80%
Employment (direct and indirect)	4000
Boats involved	100

Storm Surge barriers



How the floodgates work

Defence against exceptionally high tide



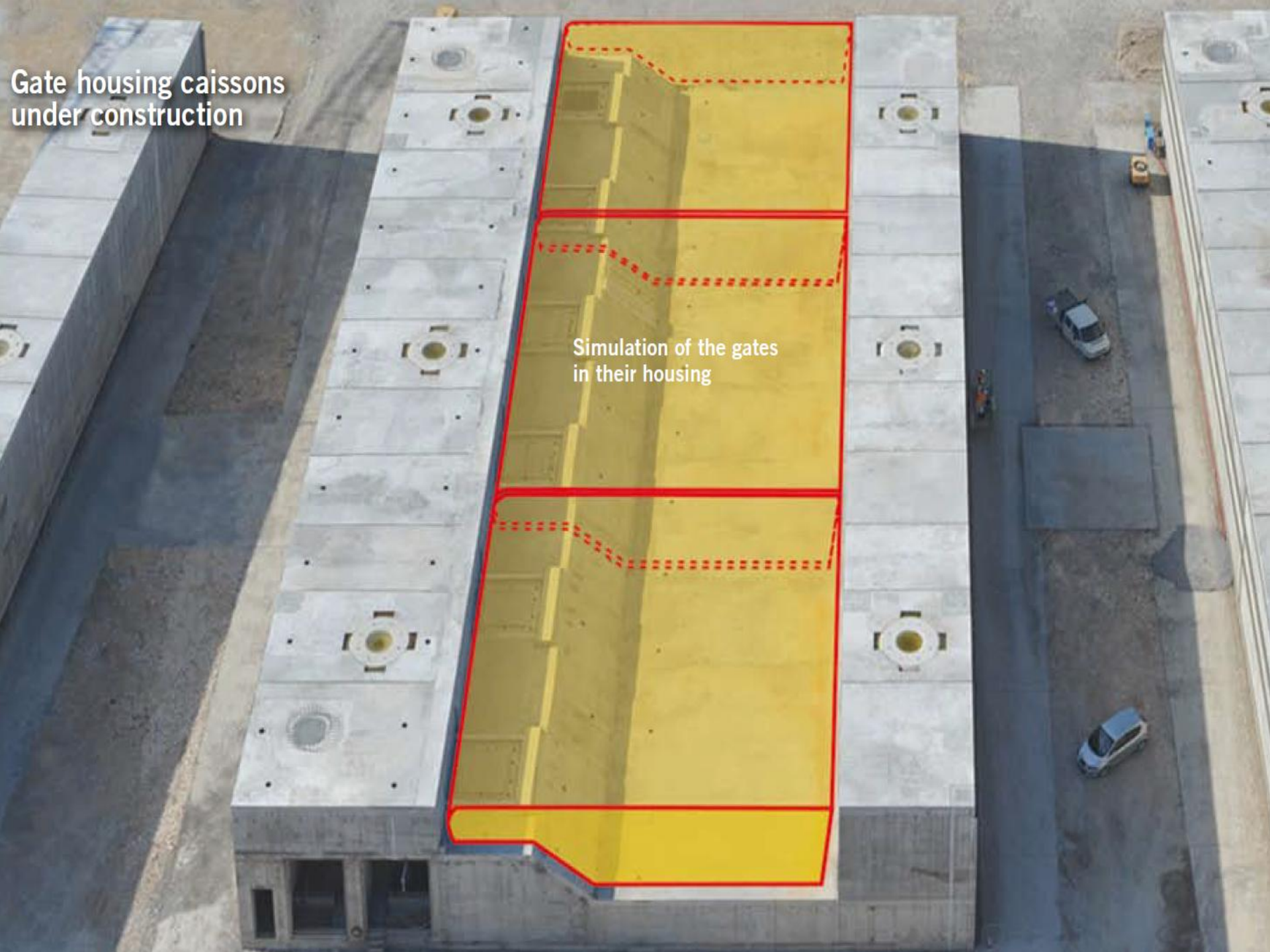
October 2013.
Monoeuvering of the first four gates in the North Lido barrier

Lido. The new lay-out

The new lay-out after realization of the Mose System

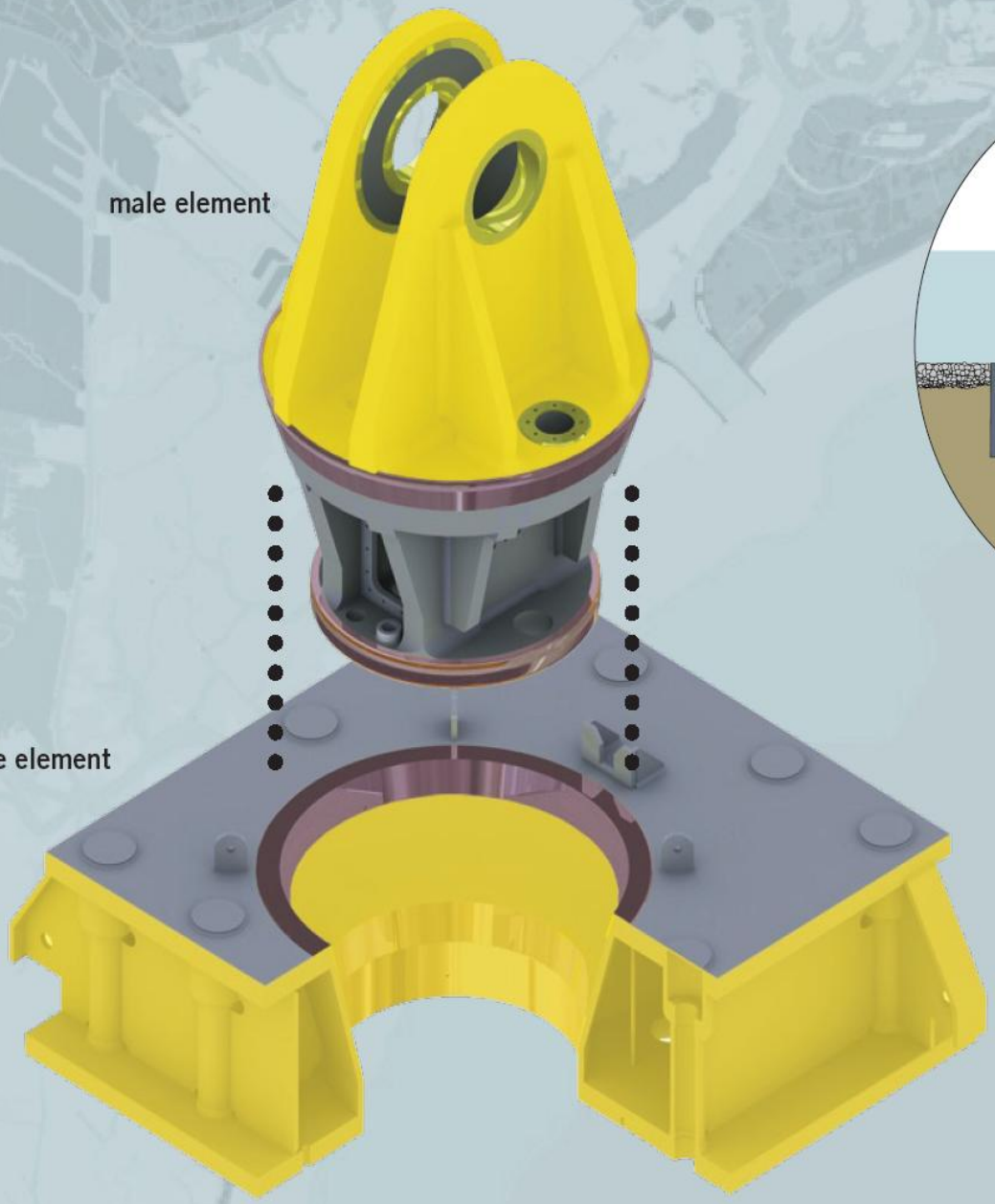
1. Refuge haven with lock
2. Row of gates (Lido - Treporti)
3. New island between the rows of gates
4. Row of gate (Lido - S. Nicolò)
5. New configuration of the south bank
6. Breakwater

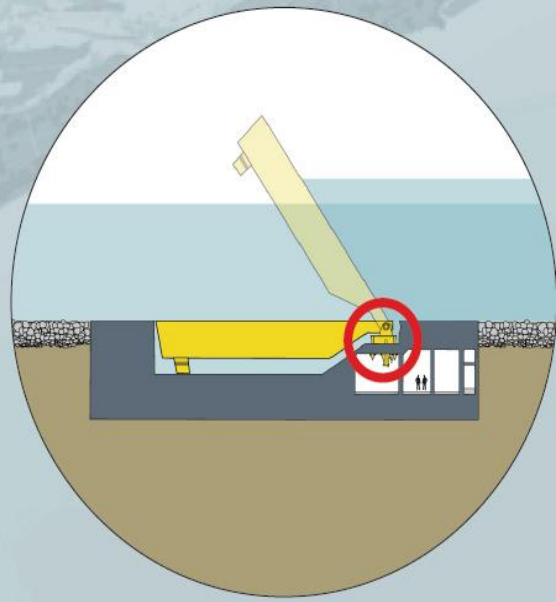
February 2012. The housing structures and the aboutments of the North Lido barrier are completed


Gate housing caissons
under construction
Simulation of the gates
in their housing

Hinge

Male and female elements

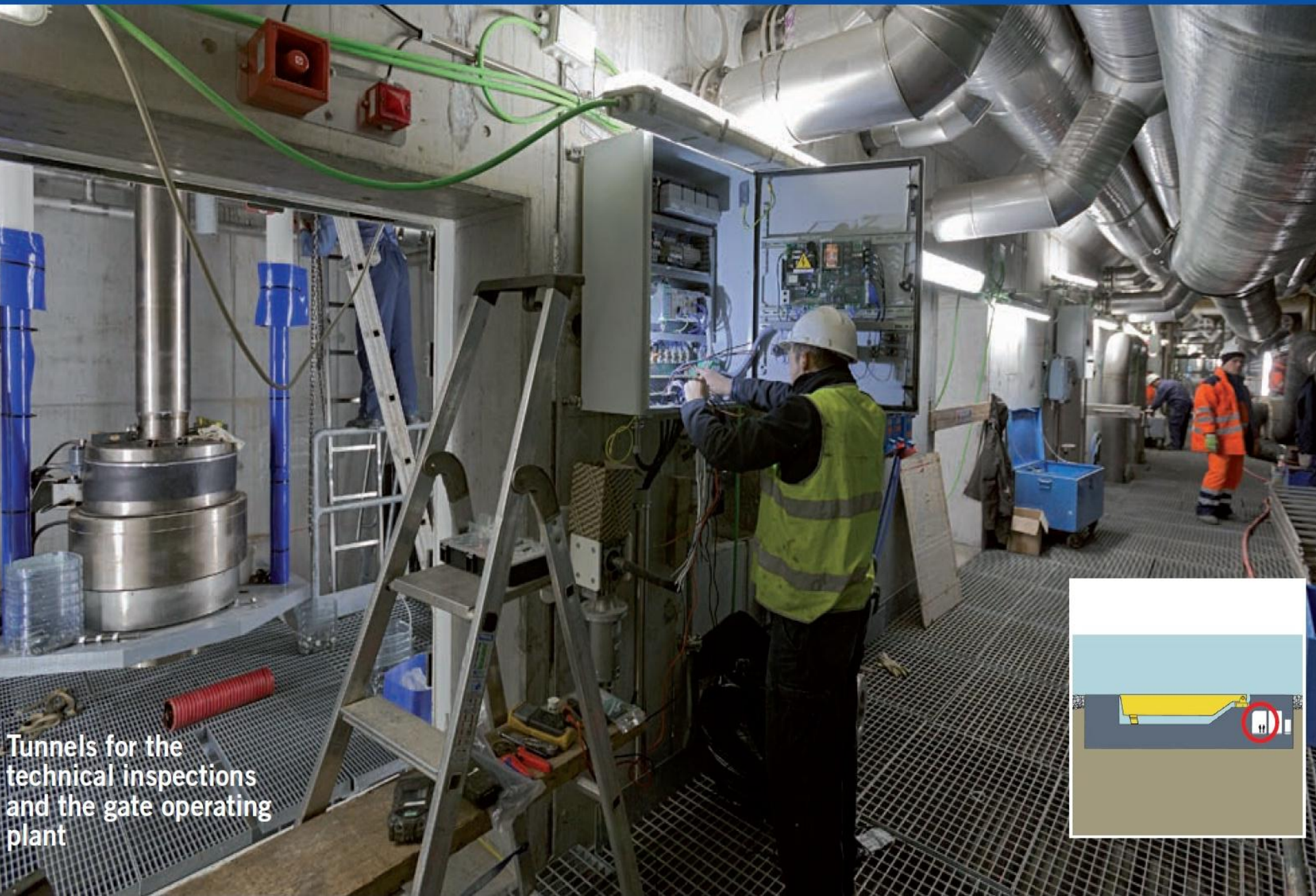




March 2012. After closing the tunnels of each housing structure with watertight doors, the basin is flooded. “Launching” of the structures begins

May 2012.
Launch of the first
abutment caisson

Lido. Caissons



Tunnels for the technical inspections and the gate operating plant

Gates

Arrival in the lagoon
of the first two gates

Gates

Preliminary works before the installation of the gates for the North Lido barrier. Connection of the male hinge

Lido. The inlet today

The dry docks

The Mose Control Centre.
The Operation Room