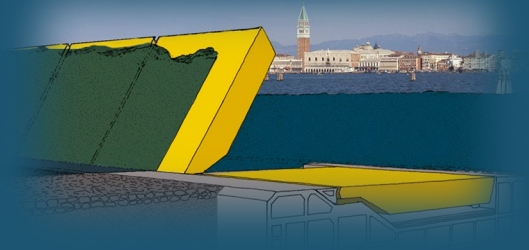
World Conference for TOKYO Resilience: Aiming for " *Safety for the Next 100 Years*"

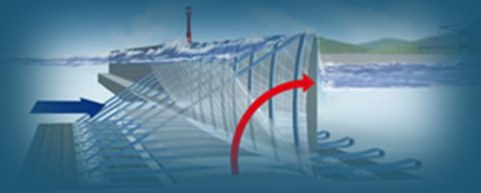
8 May 2024 Italian Cultural Institute Tokyo *16:30-17:45 Pannel Discussion*

Building Bridges of Knowledge and Practice A Path Forward Through Resilience and Collaboration



The MO.S.E. in Venice
Resilient Storm Surge Protections

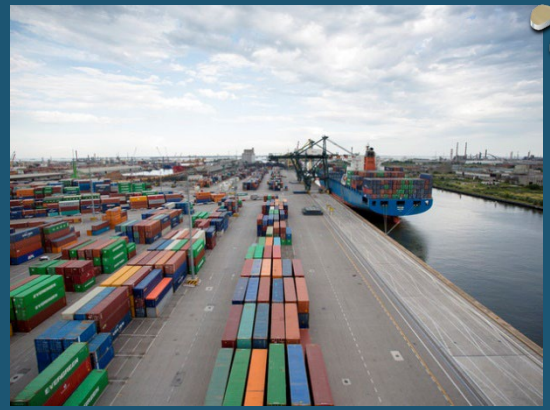
Giovanni Cecconi, Venice Community Lab
www.venicelab.net +39 3351379177 ceccogio@gmail.com



The Venice Lagoon

Sustainability / Environmental protection / Collective value

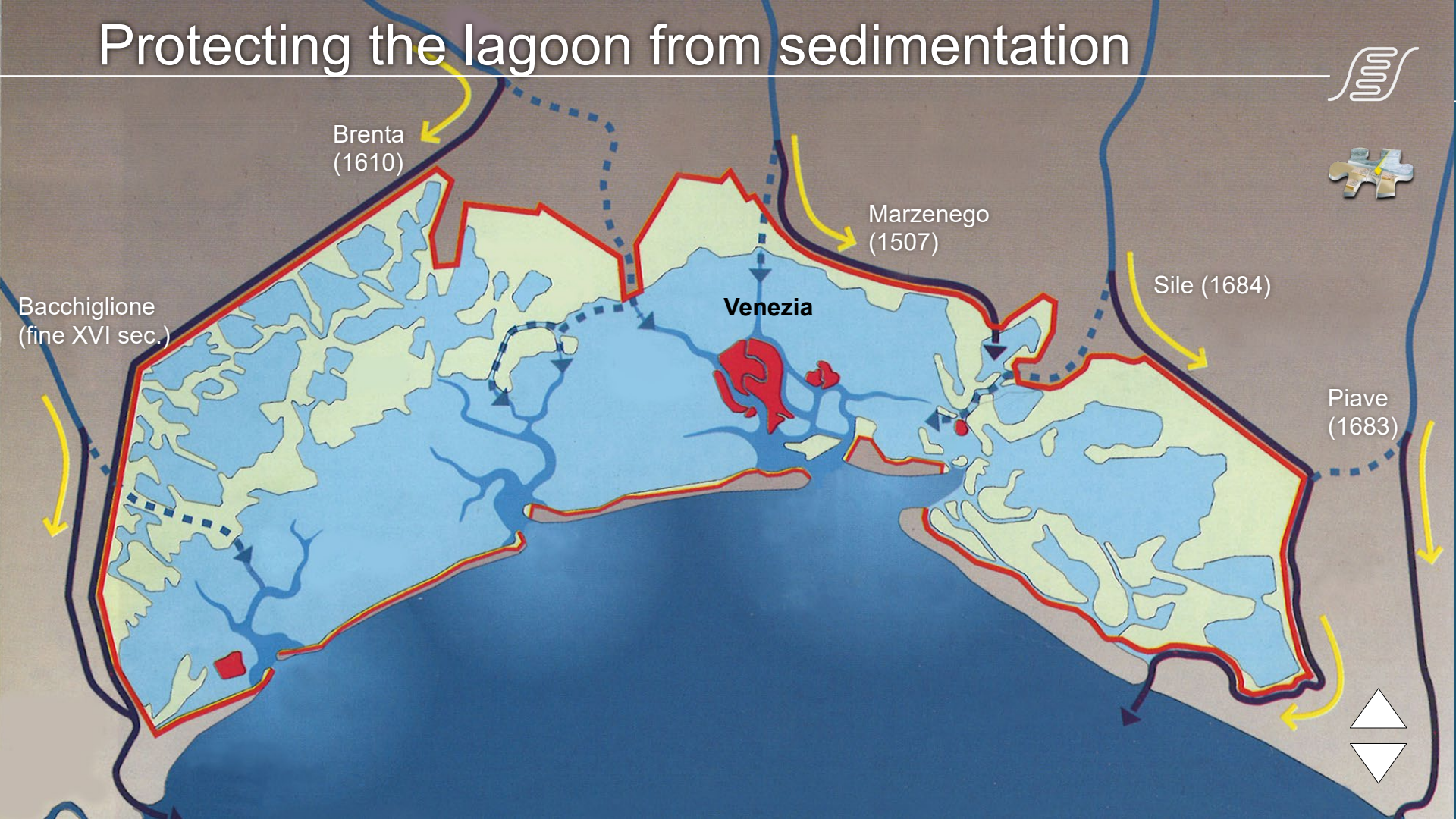
Population and economic activities



Sustainability / Environmental protection / Collective value

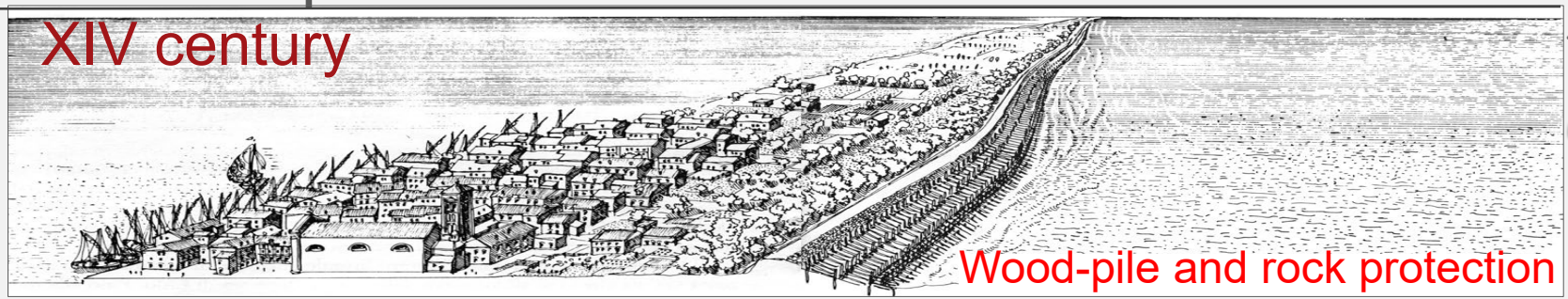
Historical, artistic and environmental heritage

Protecting the lagoon from sedimentation

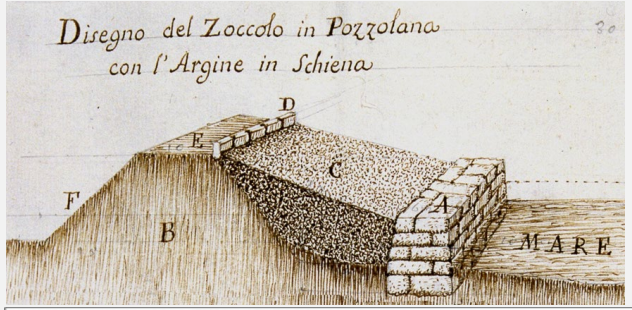


Coastal protection

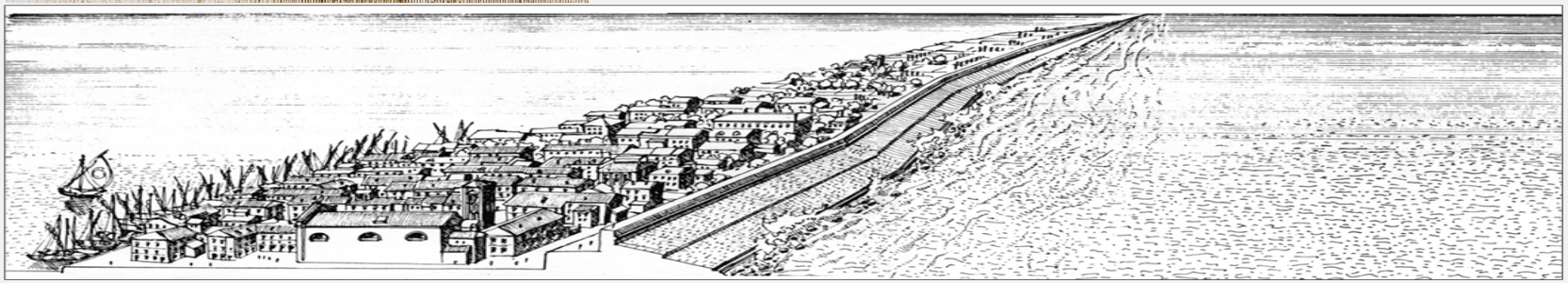
XIV century



Wood-pile and rock protection



Reinvention of Pozzolanic cement



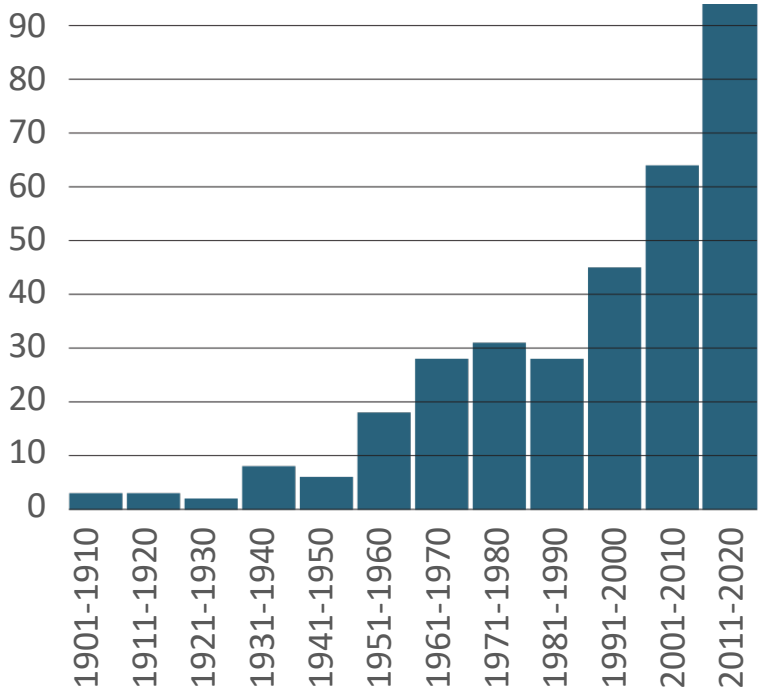
Flood
12 november 2019

187 cm


Incresed frequency of flooding

CLIMATE CHANGE :

10 X frequent floods and 6 X extreme floods >148 cm



4 novembre 1966	194 cm
12 novembre 2019	187 cm
22 dicembre 1979	166 cm
1 febbraio 1986	159 cm
1 dicembre 2008	156 cm
29 ottobre 2018 (h 14,40)	156 cm
15 novembre 2019	154 cm
12 novembre 1951	151 cm
17 novembre 2019	150 cm
11 novembre 2012	149 cm
29 ottobre 2018 (h 20,25)	148 cm

22 novembre 2022 - attivazione Mose (187cm)

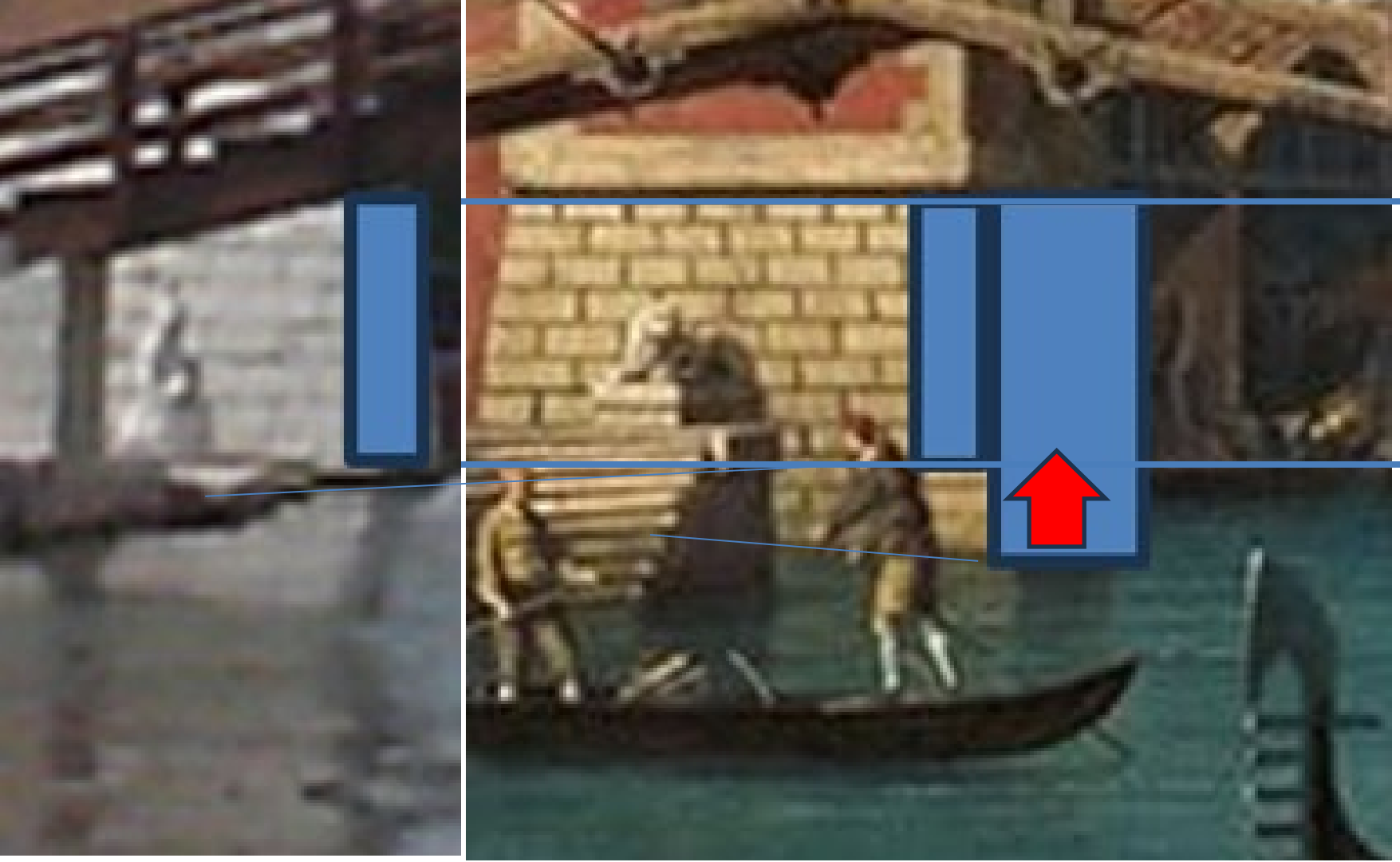
Extreme high water in Venice

6X extreme floods >148 cm

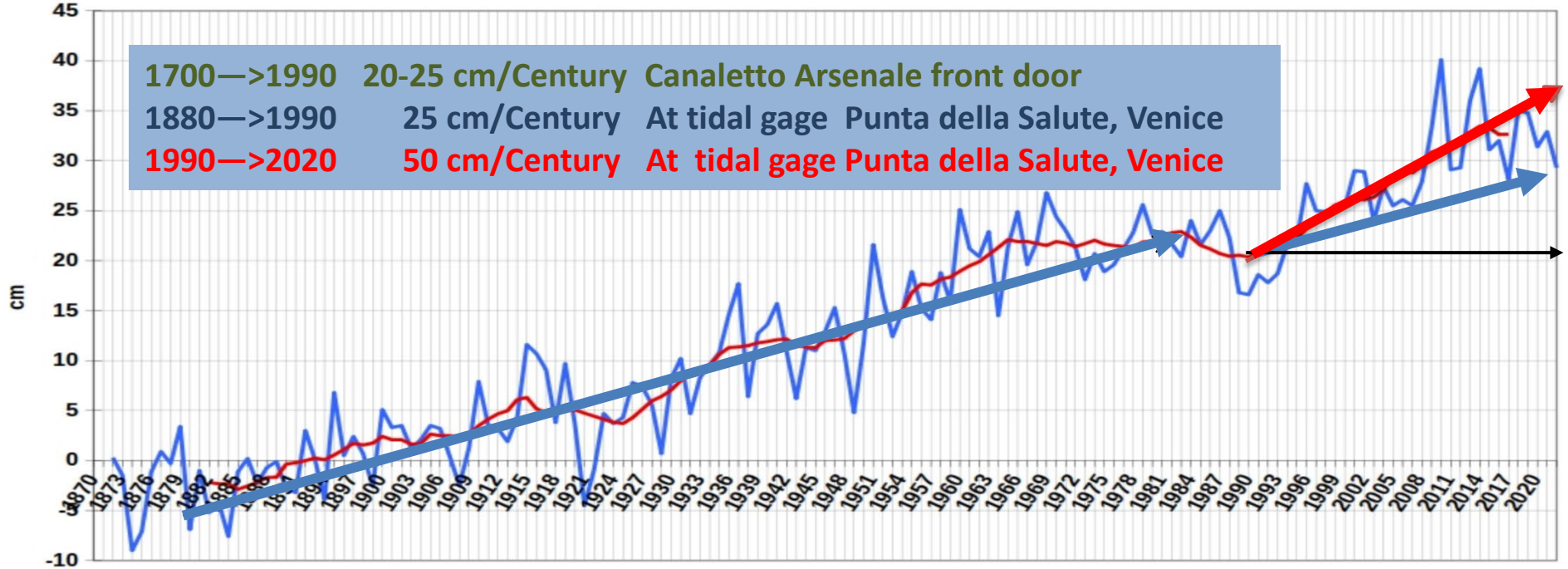
4 novembre 1966	194 cm
12 novembre 2019	187 cm
22 dicembre 1979	166 cm
1 febbraio 1986	159 cm
1 dicembre 2008	156 cm
29 ottobre 2018 (h 14,40)	156 cm
15 novembre 2019	154 cm
12 novembre 1951	151 cm
17 novembre 2019	150 cm
11 novembre 2012	149 cm
29 ottobre 2018 (h 20,25)	148 cm

22 novembre 2022 - attivazione Mose (187cm)

1720

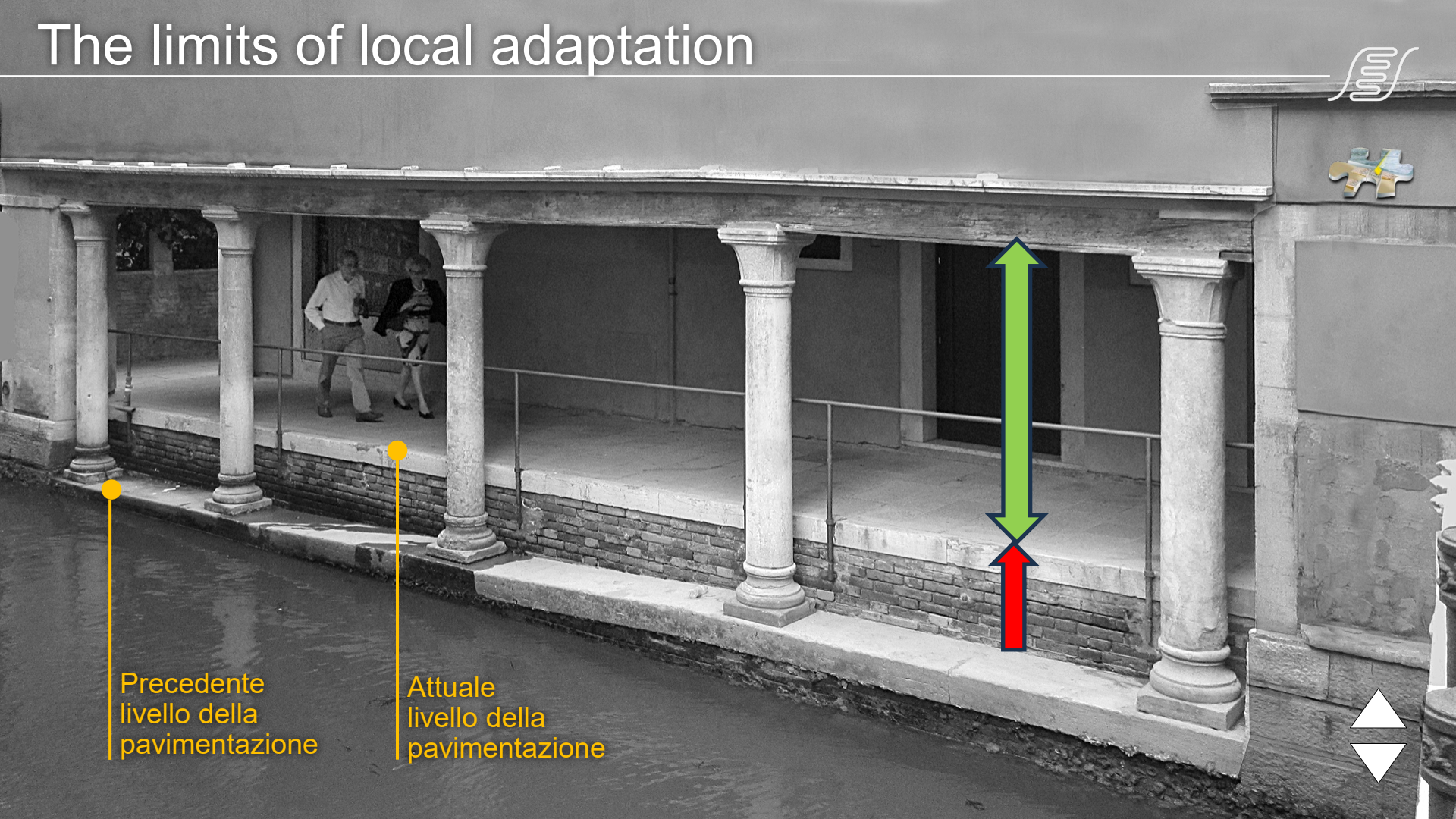


IN THE LAST 30 YEAR THE TREND HAS DOUBLED TO 50 CM /CENTURY



(Changes of the mean sea level in Venice from 1872 to 2022 and 11-years moving average)

The limits of local adaptation



What has been done by Consorzio Venezia Nuova, Concessionaire of Magistrato Acque, Min.Pub.Works, in 35 years, spenditure of 12 billion euro

Pollution controll and Nature based solutions with the reuse of Dredged Sediments

PROTECTED BEACH NOURISHMENT

URBAN ADAPTATION

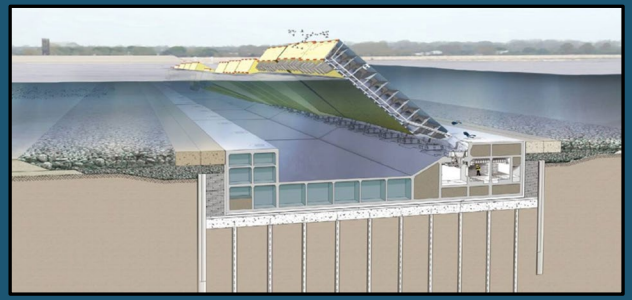
STORM SURGE BARRIERS AT LAGOON INLETS

Mose System a combined solution

Local Protection: tide<110cm

&

Mobile Barriers: tide >110cm



Lagoon

Sea

Local defence

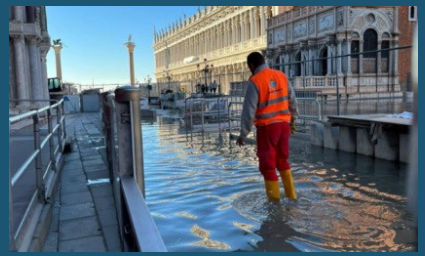
Mobile barriers

MO.S.E. as a flexible system

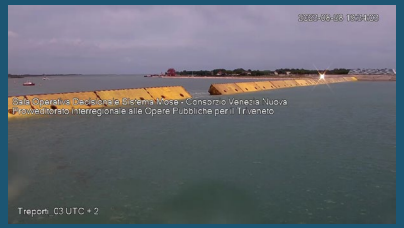
General Strategy

SHIP DELAYS
PORT AUTHORITY'S
OPERATIONAL NEEDS

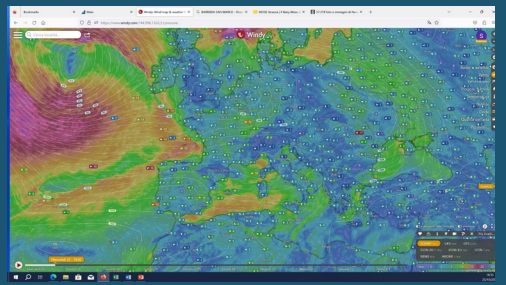
LOCAL PROTECTIONS
BABY MOSE IN CHIOGGIA
AND
ST. MARK'S



PLANTS
POSSIBLE SYSTEM
PROBLEMS



METEO MARINE MARINE DATA
AND FORECASTS



MO.S.E. as a flexible system

Differential Operations of the MOSE System

1. On/Off closures and partial closures of one or more barriers or subset of flaps in each a barrier

1. Water quality and sediment/wetland issues

MO.S.E. as a flexible system

On/Off Use:

- A single closure
- More closures to deal with particular weather situations
- Modulated closures (Need to close/reopen Chioggia and/or Malamocco for special navigational needs)
- Partial closure (only Lido) to reduce the impact on navigation and induce tidal flushing

MO.S.E. as a flexible system

Water quality and sediment/wetland issues and nesting

Preventing pollution

Easy the collection spillage of pollutants in the lagoon

or prevente inputs from the sea or rivers

Environmental Use

Induce tidal flushing against anoxia

Reduce sediment loss from tidal flats to channels and sea

Facilitate Wetland starting process

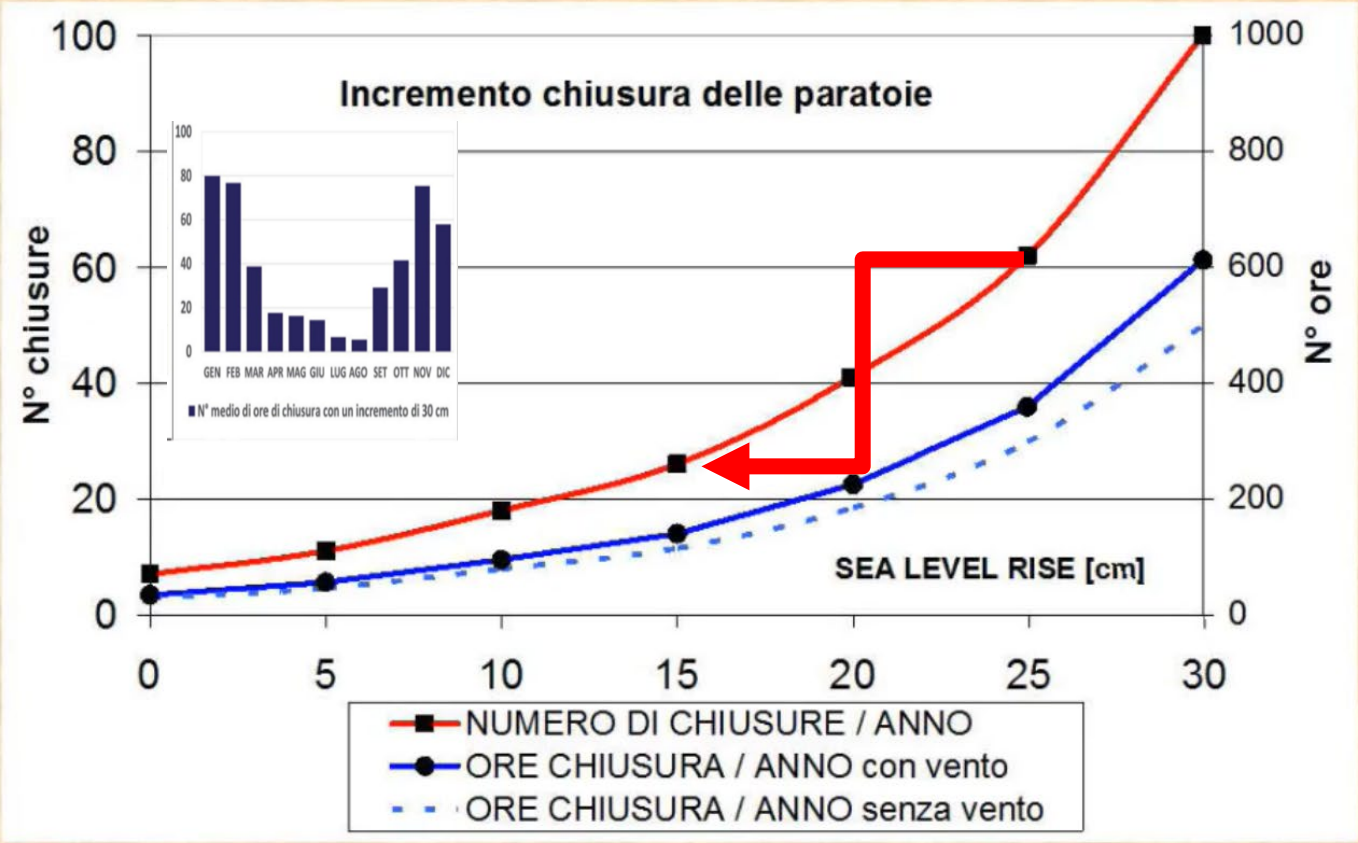
Bird nesting and reproduction

Unexpected new island induced by the Mose closures limiting winter shoal overtopping

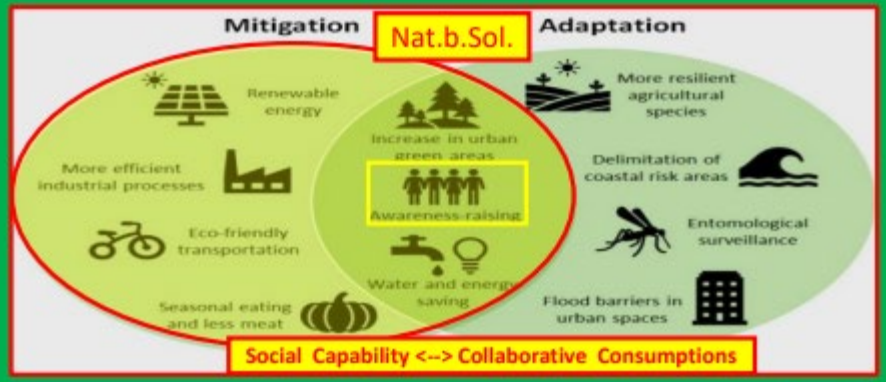
Concluding remarks

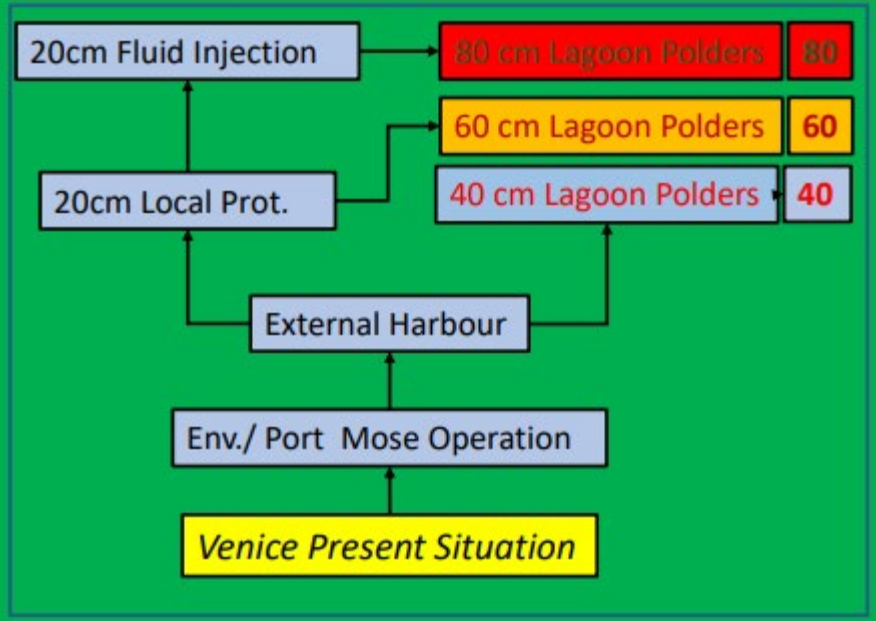
- **Venice protected** from floods in times of climate change and the **quality of the environment** has been improved.
- Great **flexibility** thanks to possibility to operate the system with partial closure of the barriers for environmental and social benefits
- **Multi-disciplinary knowledge** and experience in managing complex socio-ecological system (I-Storm founding member)
- Venice is an easy accessible ***living lab*** for other coastal cities facing climate and social changes

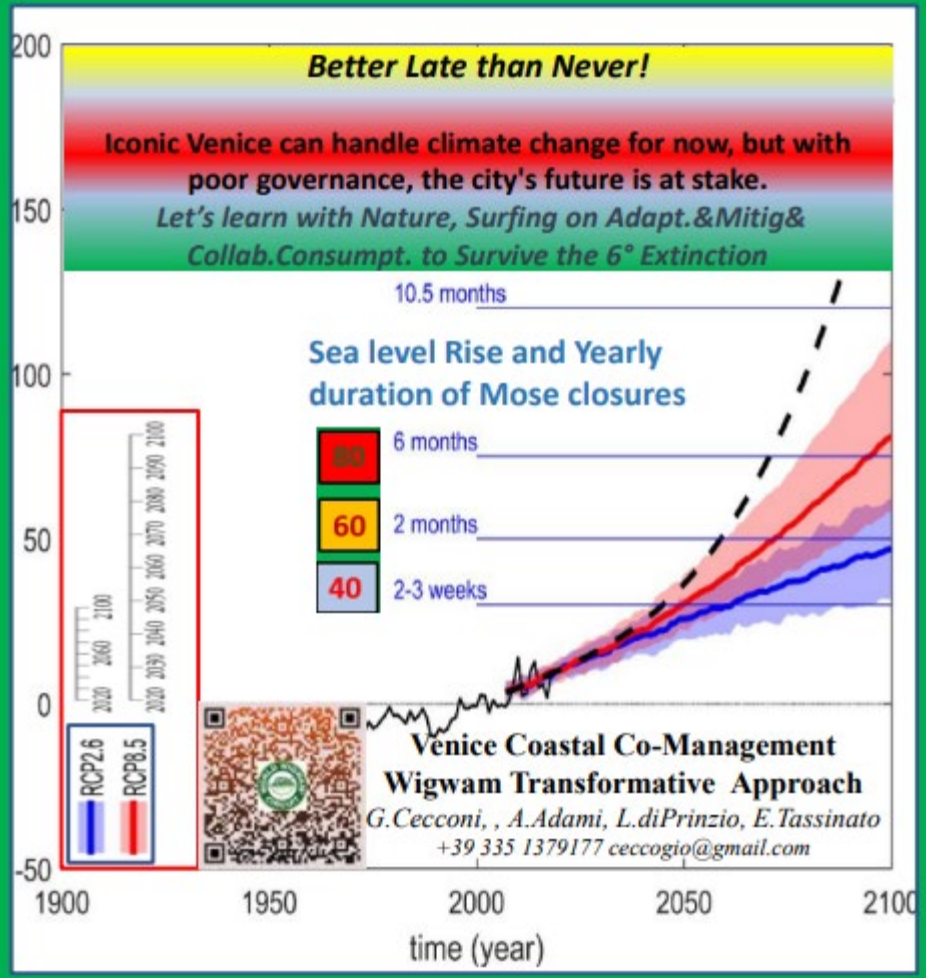
COPING WITH SEA LEVEL RISE : Closing only Lido in 65% flood case; Increase the loc. prot. of 10-20 cm



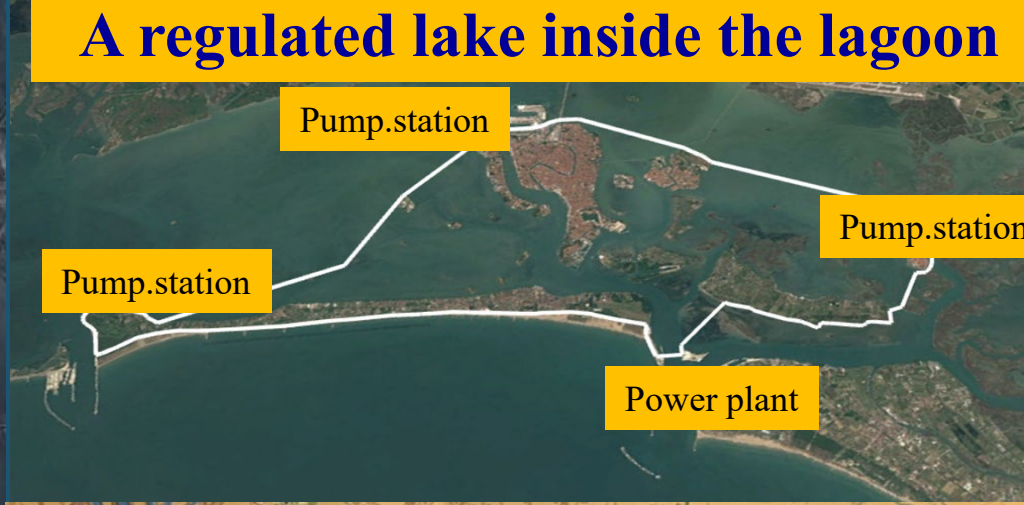
Le barriere mobili è probabile che, come conseguenza degli effetti congiunti dei dislivelli generati dal vento e dell'eustatismo debbano essere manovrate d'inverno quasi tutti i giorni


Mitigation
Nat.b.Sol.
Adaptation
Renewable energy
More efficient industrial processes
Eco-friendly transportation
Seasonal eating and less meat
Increase in urban green areas
Awareness-raising
Water and energy saving
More resilient agricultural species
Delimitation of coastal risk areas
Entomological surveillance
Flood barriers in urban spaces
Social Capability <--> Collaborative Consumptions


20cm Fluid Injection
80 cm Lagoon Polders
80
60 cm Lagoon Polders
60
20cm Local Prot.
40 cm Lagoon Polders
40
External Harbour
Env./ Port Mose Operation
Venice Present Situation


Better Late than Never!
Iconic Venice can handle climate change for now, but with poor governance, the city's future is at stake.
Let's learn with Nature, Surfing on Adapt.&Mitig& Collab.Consumpt. to Survive the 6° Extinction
10.5 months
Sea level Rise and Yearly duration of Mose closures
80
6 months
60
2 months
40
2-3 weeks
RCP2.6
RCP8.5
200
150
100
50
0
-50
1900
1950
2000
2050
2100
time (year)
Venice Coastal Co-Management
Wigwam Transformative Approach
G.Cecconi, , A.Adami, L.diPrinzio, E.Tassinato
+39 335 1379177 ceccogio@gmail.com

A regulated lake inside the lagoon



The Sandy Dike:

Bike and rails

Park trees

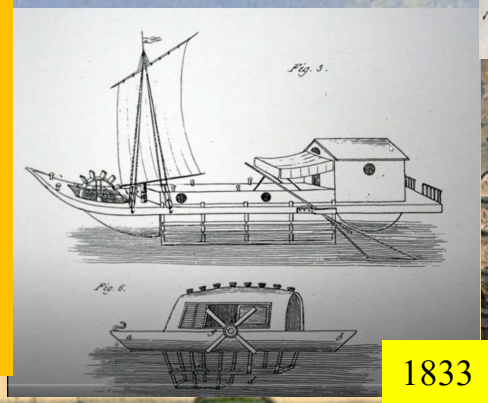
Local Food Garden

Sea Resort

Venice

Swimmable

Again



1833

1700

1950

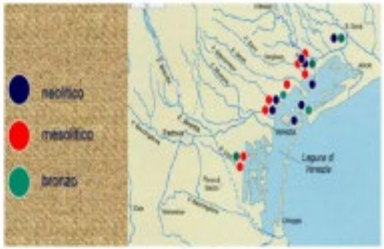
1833

Venice After Mose

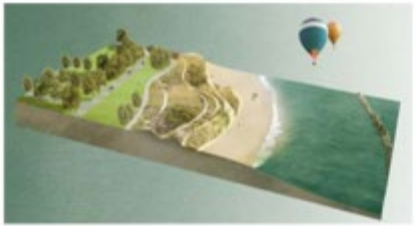
A Lagoon Water Farm

Co-evolution

Back to the future

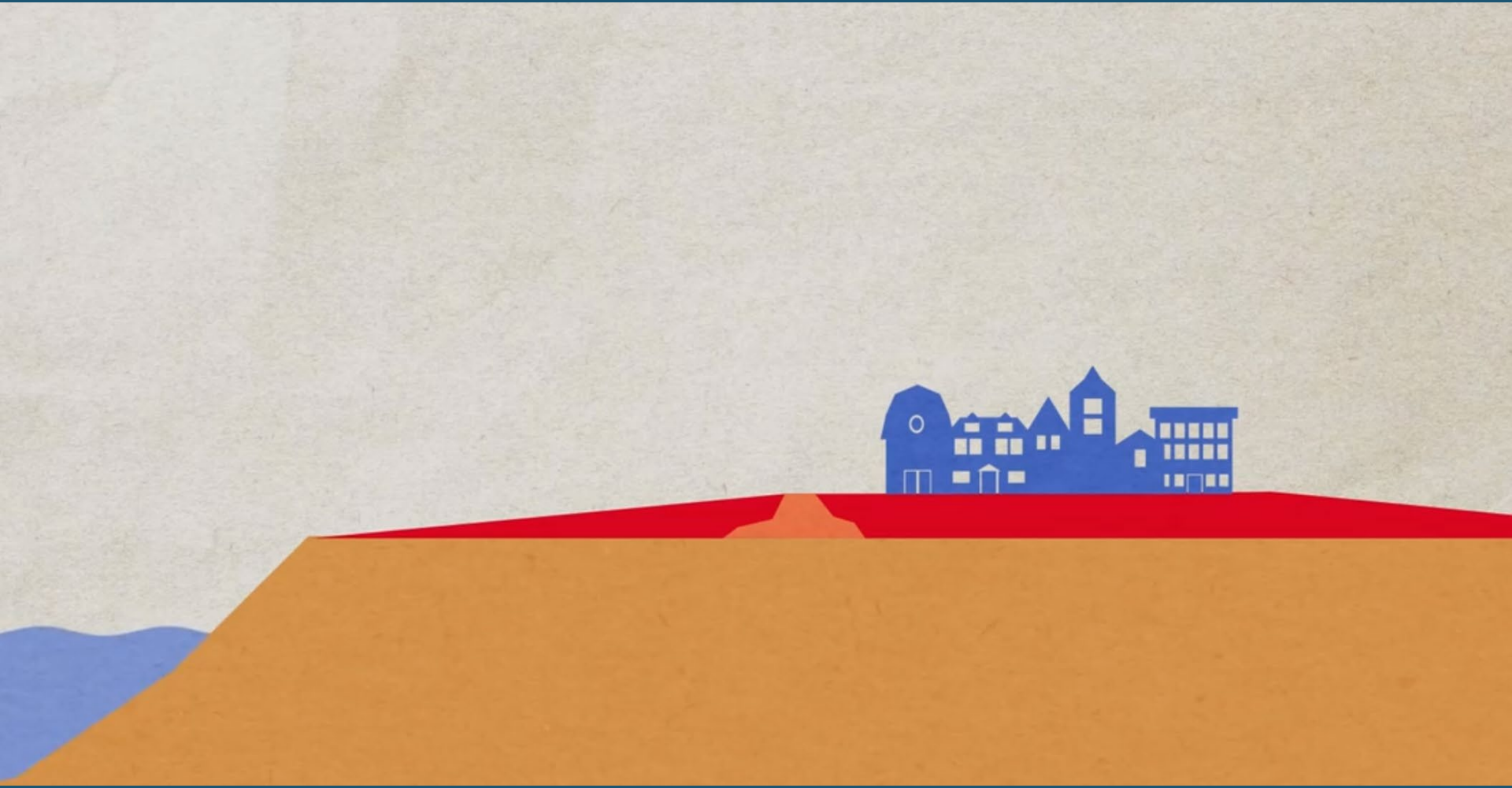


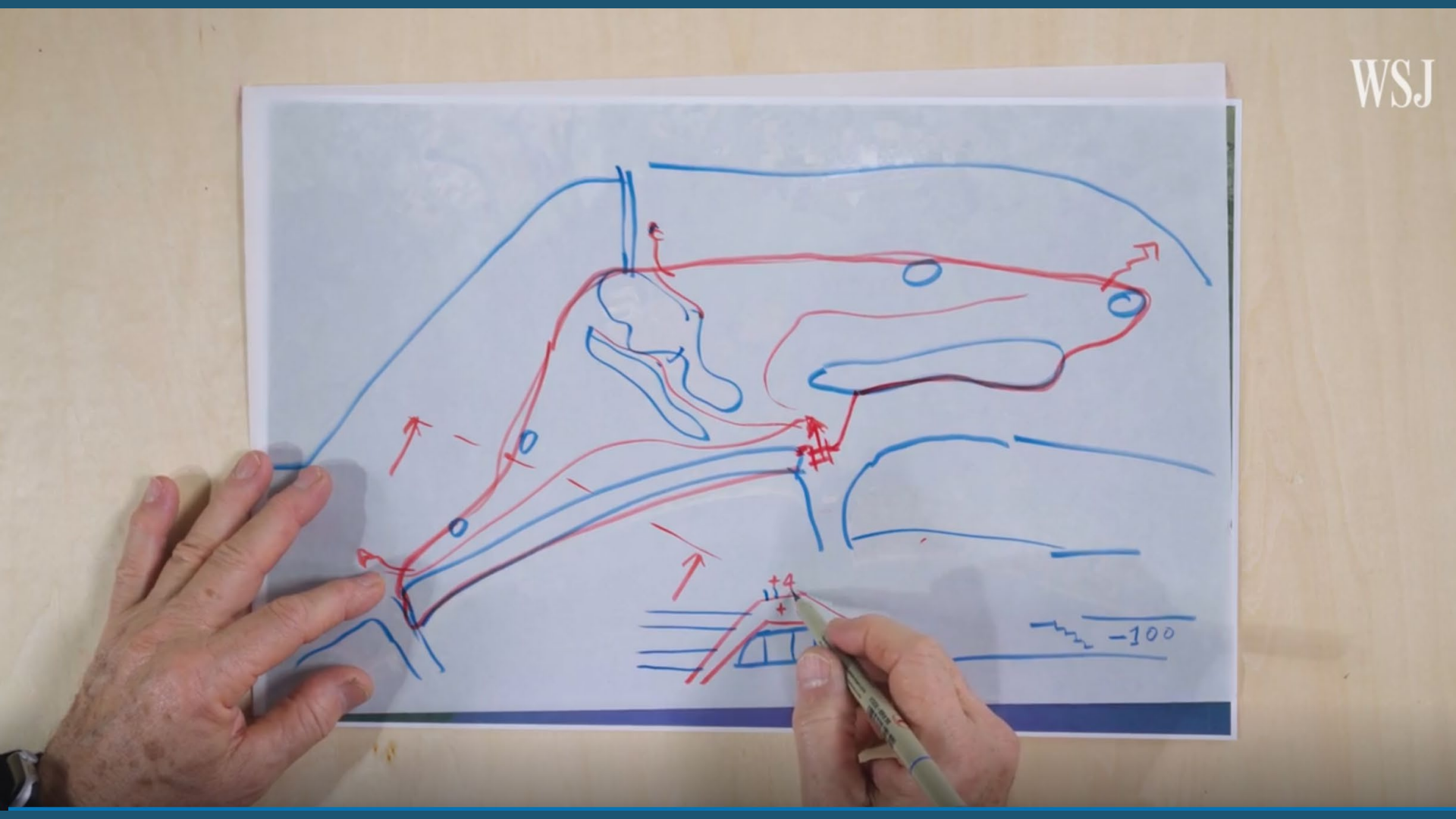
Regulated waters, horticulture, urban park, inner littoral, power production, renewable energies, safe fishing and marinas around the historical city



ATTILIO ADAMI
GIOVANNI CECCONI


WSJ




+4
-100

Venice Lab Adaptive Hospitality

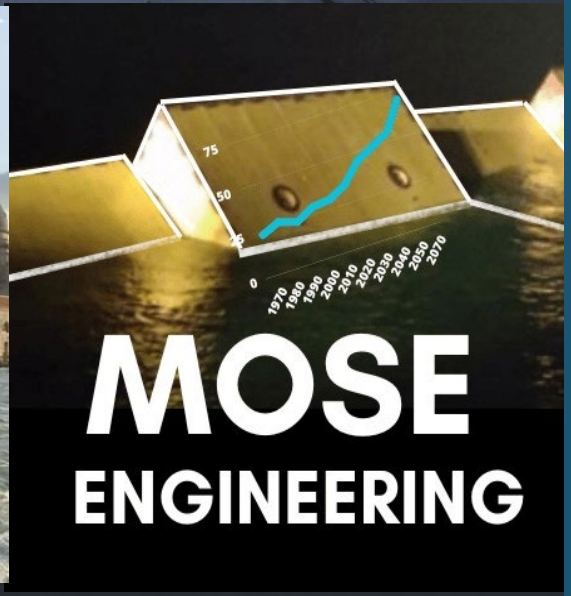
Venice continue to be the oldest city of the future
practicing formal and informal exchanges
with other water cities
for environmental restoration and disaster risk reduction.

This knowledge is also available both by institutional exchanges and by local community interactions (Bottom-Up) for adaptive hospitality

Thank you for your attention !

Ing. Giovanni Cecconi
Former dir. of the Mose Information Service
& Control Room of Consorzio Venezia Nuova
Ministry of Transport and Public Works
www.mosevenezia.eu

VENICE LAB



Founder of
Venice Lab Adaptive Hospitality for Global Communities
ceccogio@gmail.com www.venicelab.eu

Mose System

Constraints, guidelines and design criteria

A. The system of defence against high waters must not introduce significant changes in :

- *the water exchange at the inlets*
- *the landscape*
- *the economic activities*

B. Maintain the characteristics of experimental, reversible and gradual

G. Cecconi, E.Zambardi at Treporti Conducting the First Mose Full ClosureTest

28.Nov.2014

Testing 4 Gates Oct.2013

Work started 2003; Start of Flood protection 3.Oct.20;
Main Completion 31.12.23; Hand-over 31.12.25

Gate installation

Electromecanical Testing plants

Automation system

Commissioning and tentative flood frotection Since October 2020 operated 20 times to avoid flooding

Hand-over

31 12 2025

Treporti

2013/ 2014

2017 / 2018 **Start-up**

Operation since 3.Oct.2020

Completion of Civil Works (edifici, spalle, ecc.)

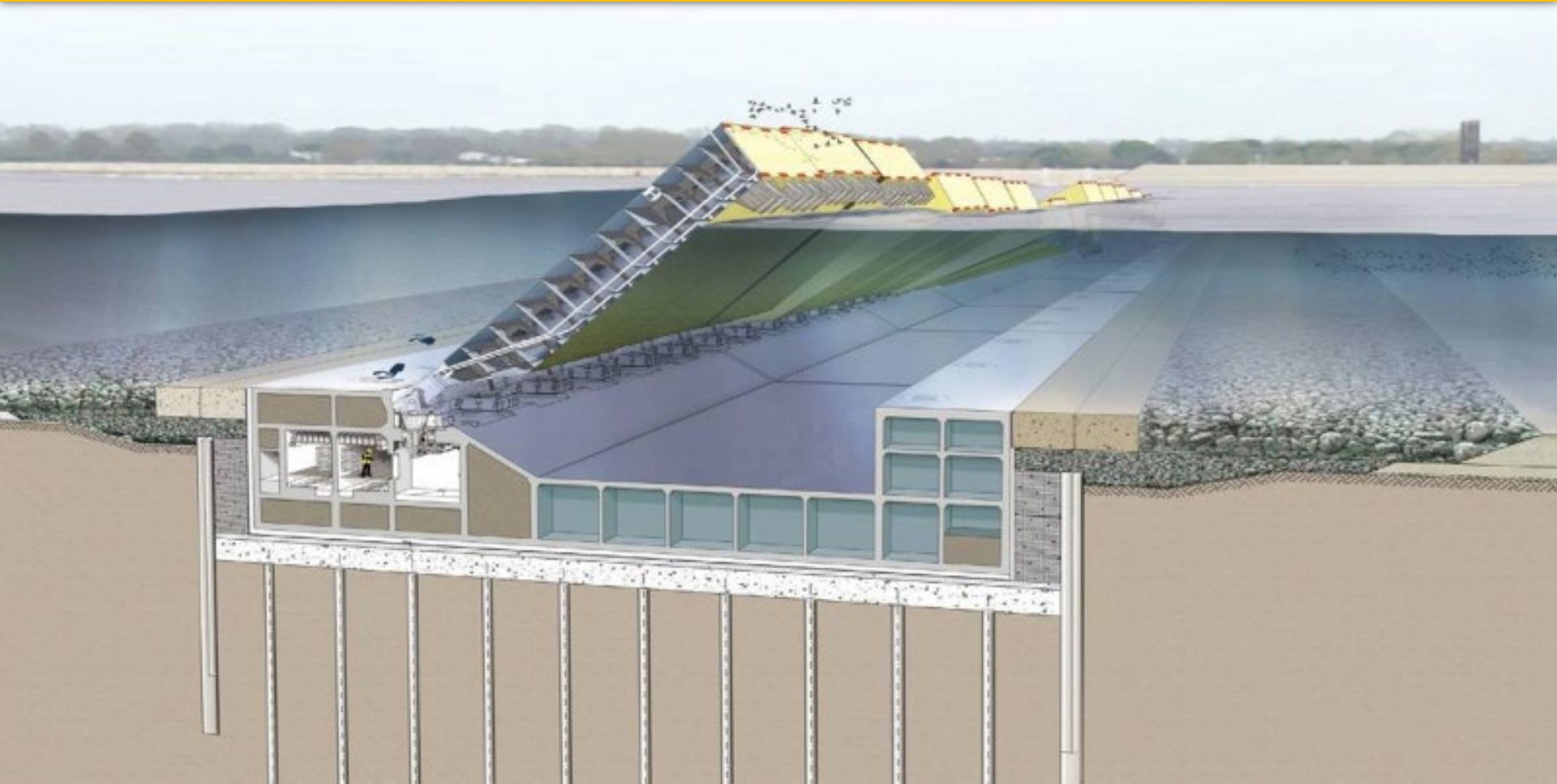
Gate Construction & Supply - Lido sud

Gate Installation Chioggia e Lido sud

Environmental monitoring

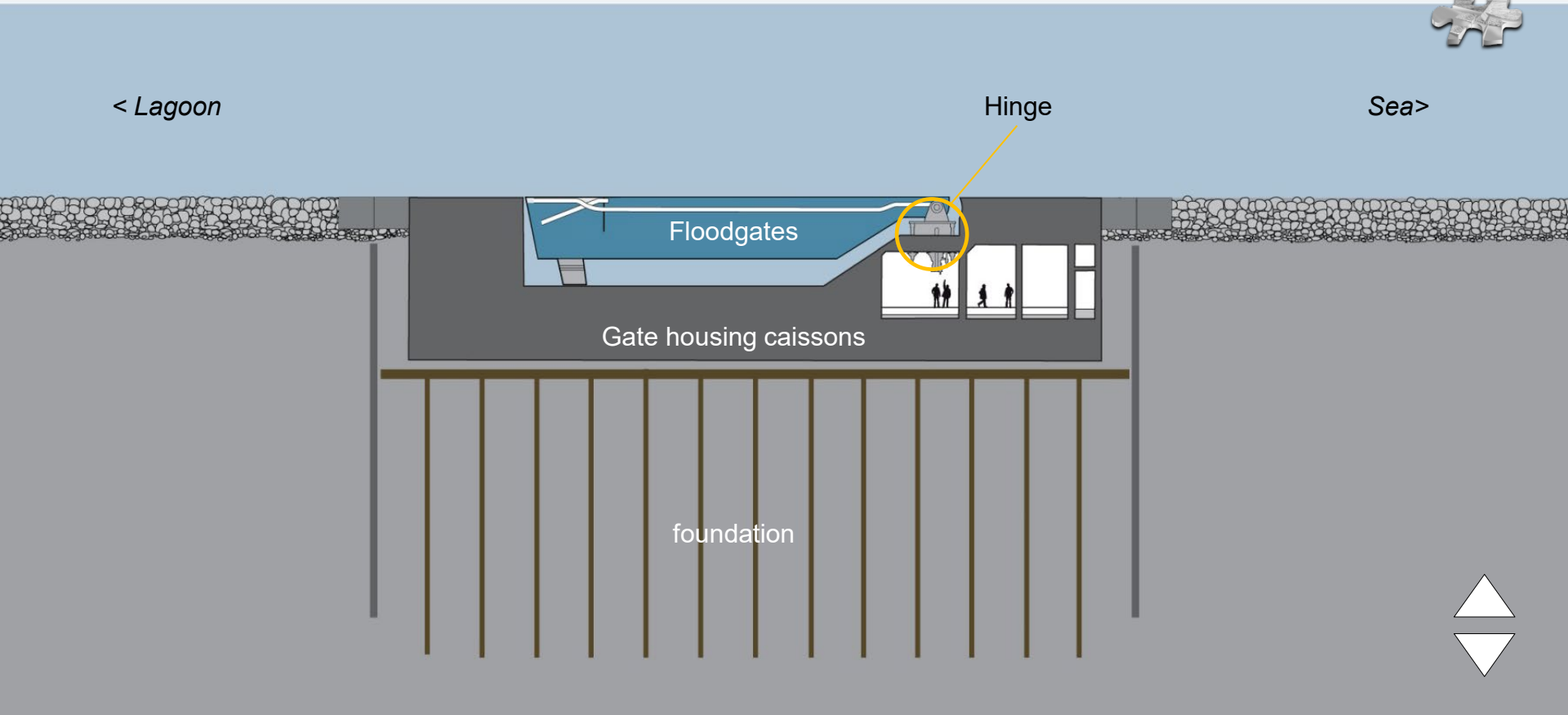
Yard Maintenance trasferred to Marghera/Fincantieri

Mose Storm Surge Barriers Foundations



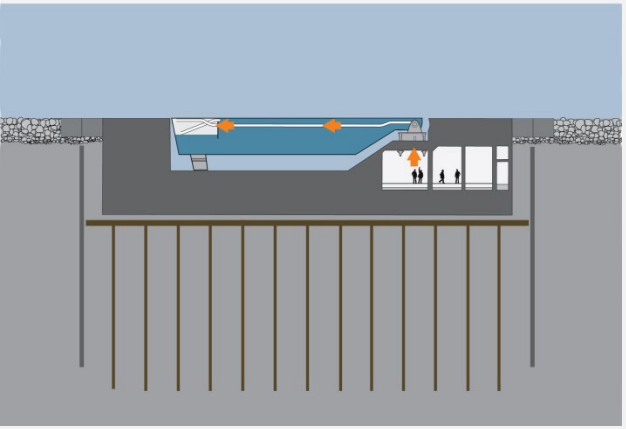
Mobile barriers

How do they work

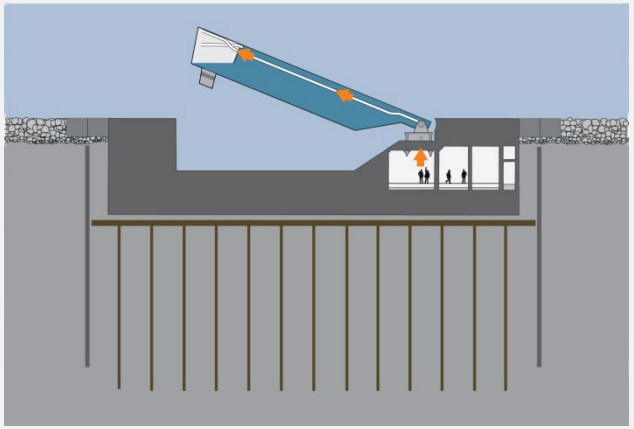


Operation

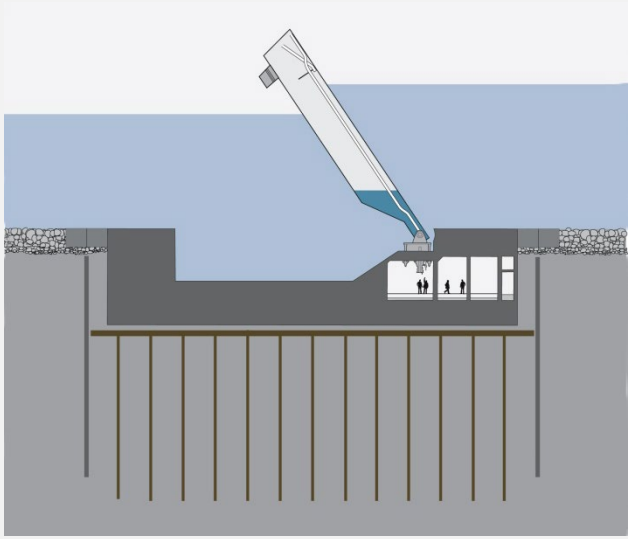
Immissione aria compressa
ed espulsione acqua



Start of lifting



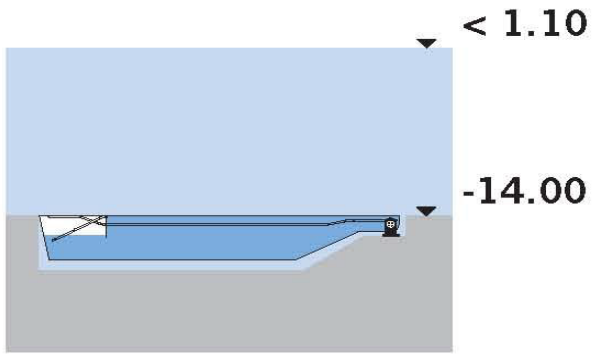
Lifting to surface



Working Position

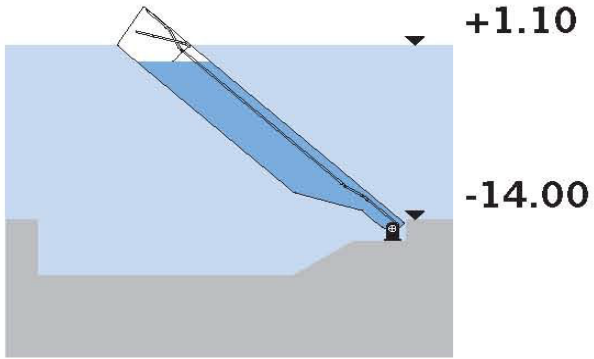
Main Components of the system

Defence against exceptionally high tide

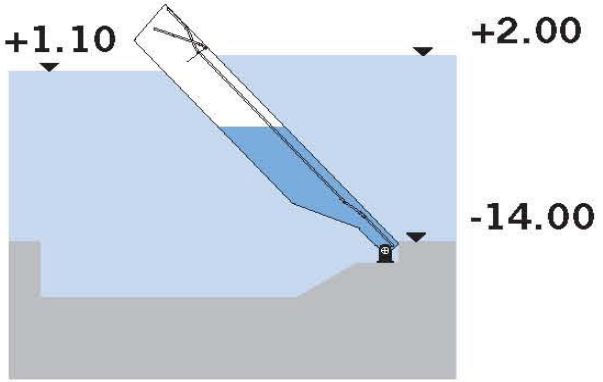


a

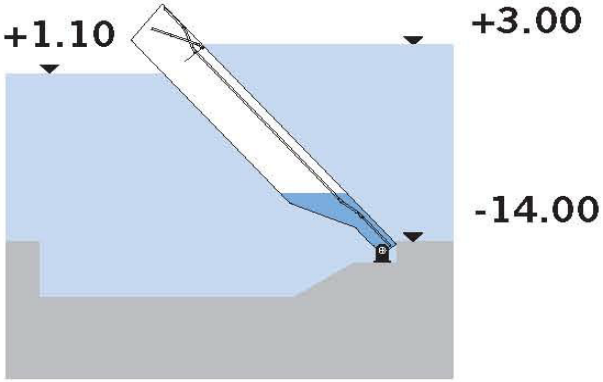
< Lagoon Sea >



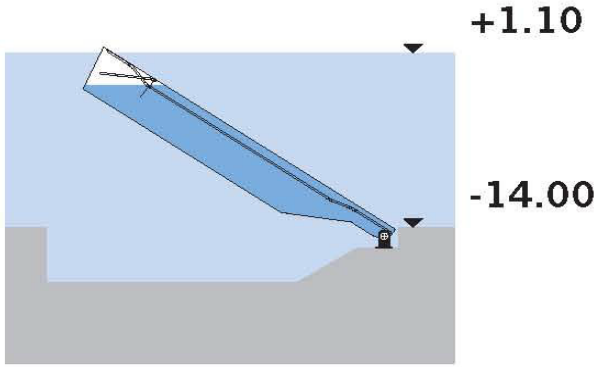
b



c



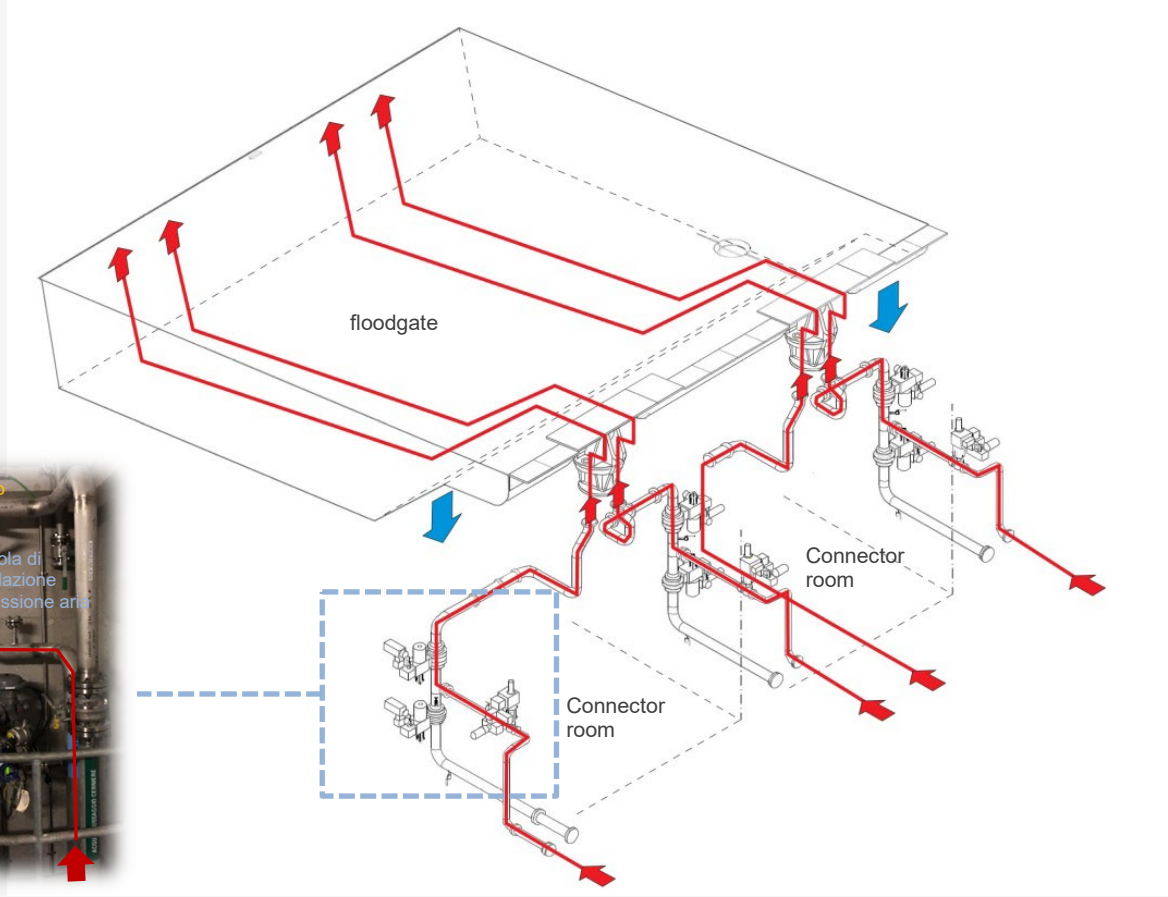
d

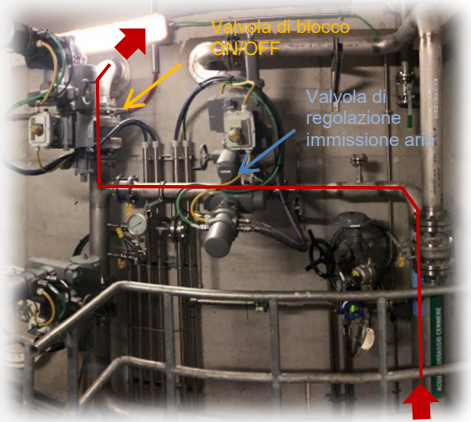


e

Mobile barriers

Pneumatic system

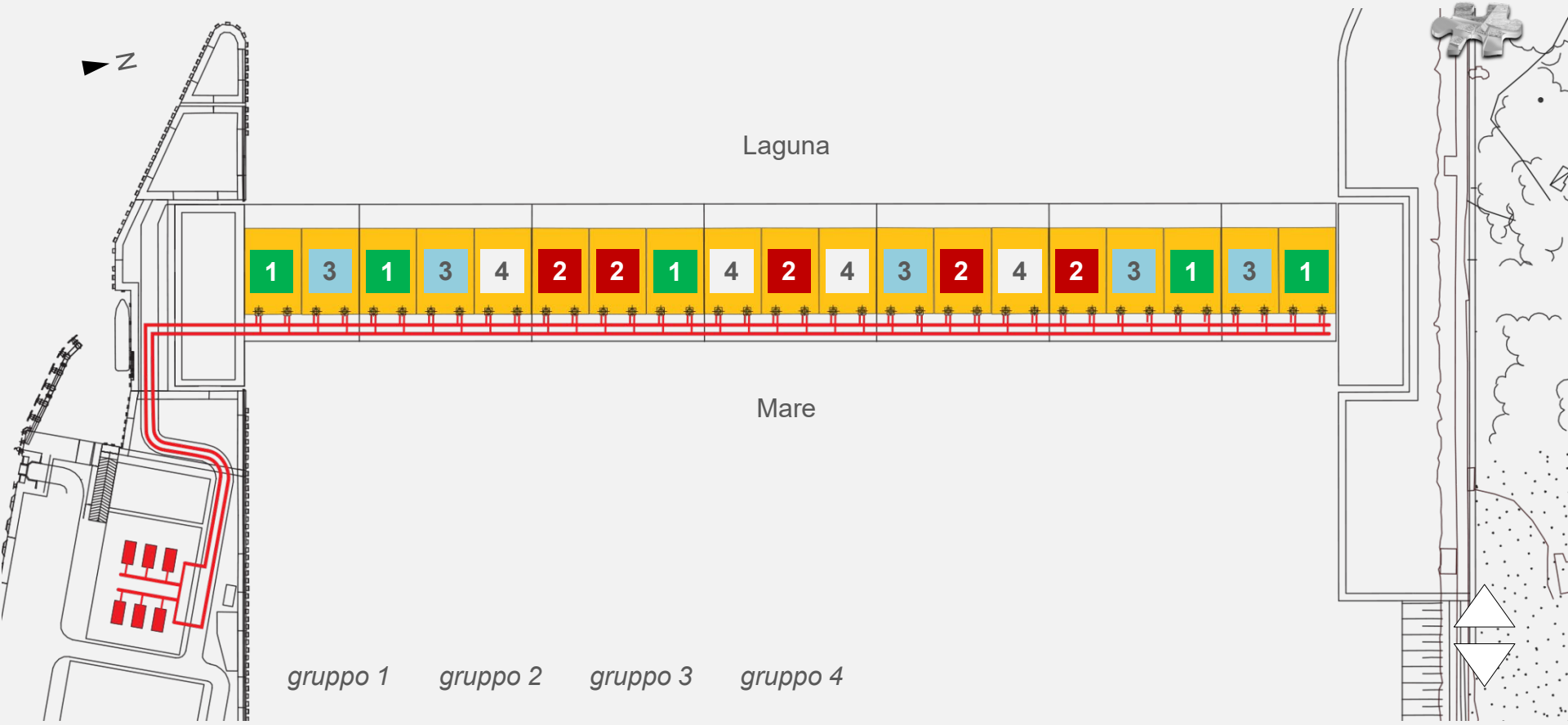




Air inlet

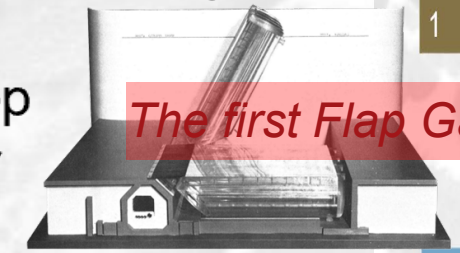
Water outlet

Lifting of the flap gates (Malamocco)

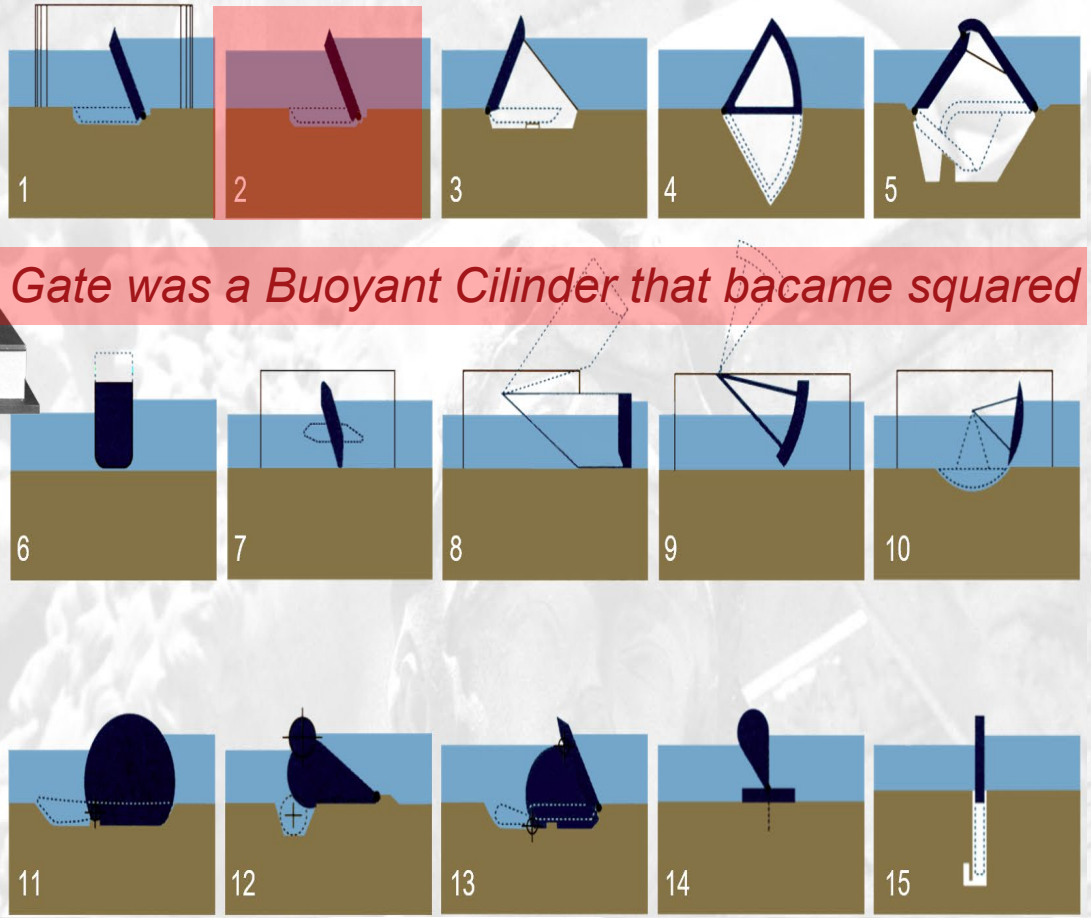


A gate chosed among many other solutions:

1. Fixed Flap Gate
2. Row of Free Flap Gates
3. Reverse Fixed Flap Gate
4. Drummer
5. Bear Trapp
6. Ship Door
7. Butterfly
8. A Helmet Concealment
9. Sector Air
10. Sector into the Bottom
11. Inflatable pillow
12. Inflatable pillow and sail
13. Mantice
14. Massive Flap on Rails
15. Buoyant Vertical caisson



The first Flap Gate was a Buoyant Cilinder that bacame squared



Nieuwpoort (concept)

Thames Barrier

Hull Barrier

Ipswich Barrier

Mose System

Marina Barrage

Maeslant Barrier

Hollandsche IJssel Barrier

Ramspol Barrier

Bayou St John Sector Gate

Lake Borgne Surge Barrier

Storm surge barriers

within the I-STORM network

Mose System
of storm surge barriers

Venezia

Laguna

Bocca di porto
di Lido

Bocca di porto
di Malamocco

Bocca di porto
di Chioggia

4
Barriers

78
Flap gates

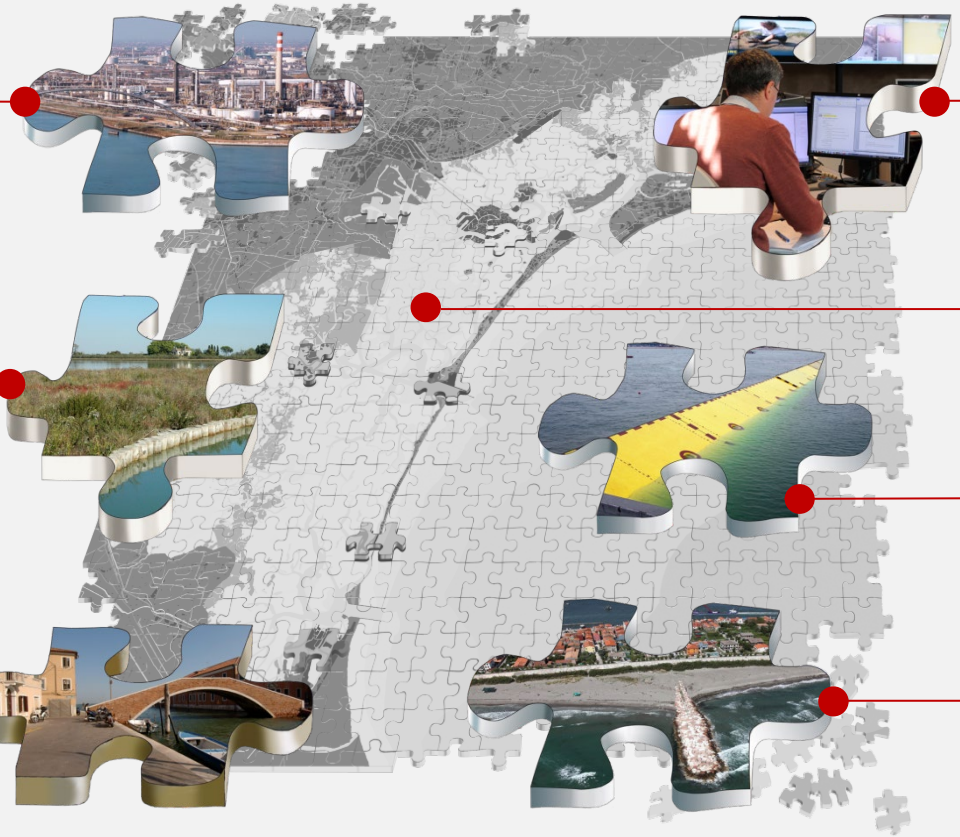
1.6 km
Total width

Lido Inlet

Malamocco inlet

Chioggia inlet

Integrated solutions for a complex system



Environmental protection

Increase environmental resilience

Increase urban resilience

Management and control

A National Venice Lab

DRR with Mobile barriers

Coastal protection

The Venice lagoon Safeguard and The Mose System

Littoral Protection

56 km protected beach nourischment
12 km constructed coastal dunes
11 Km reinforced breakwaters

MOSE 1,6 km, 78 Flap gates, 4 barriers at 3 inlets

Lido Nord 420 m; Lido Sud 400m; Malamocco 380m; Chioggia 360m

Local flood Protection

100 km of urban and lagoon embankments raised and reinforced

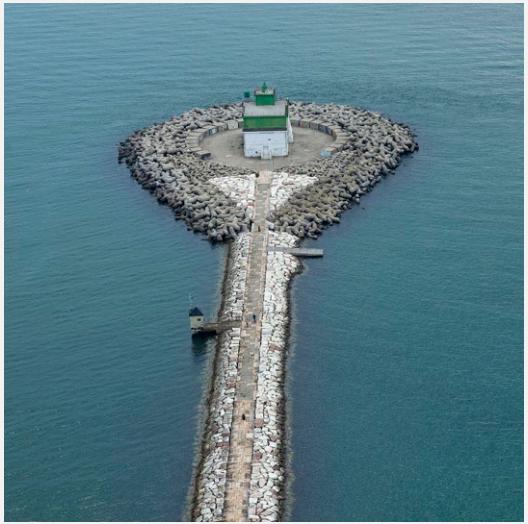
Morphological and Environmental restoration

40 km of industrial canal banks
12 islands
7 dumps sites
39 ha of phytodepuration areas
39 km wave protection of salt marshes
16 km² of *Building with Nature* salt marshes

Coastal Protection

56 km
Protected beach nourishment

12 km
Dune Restoration

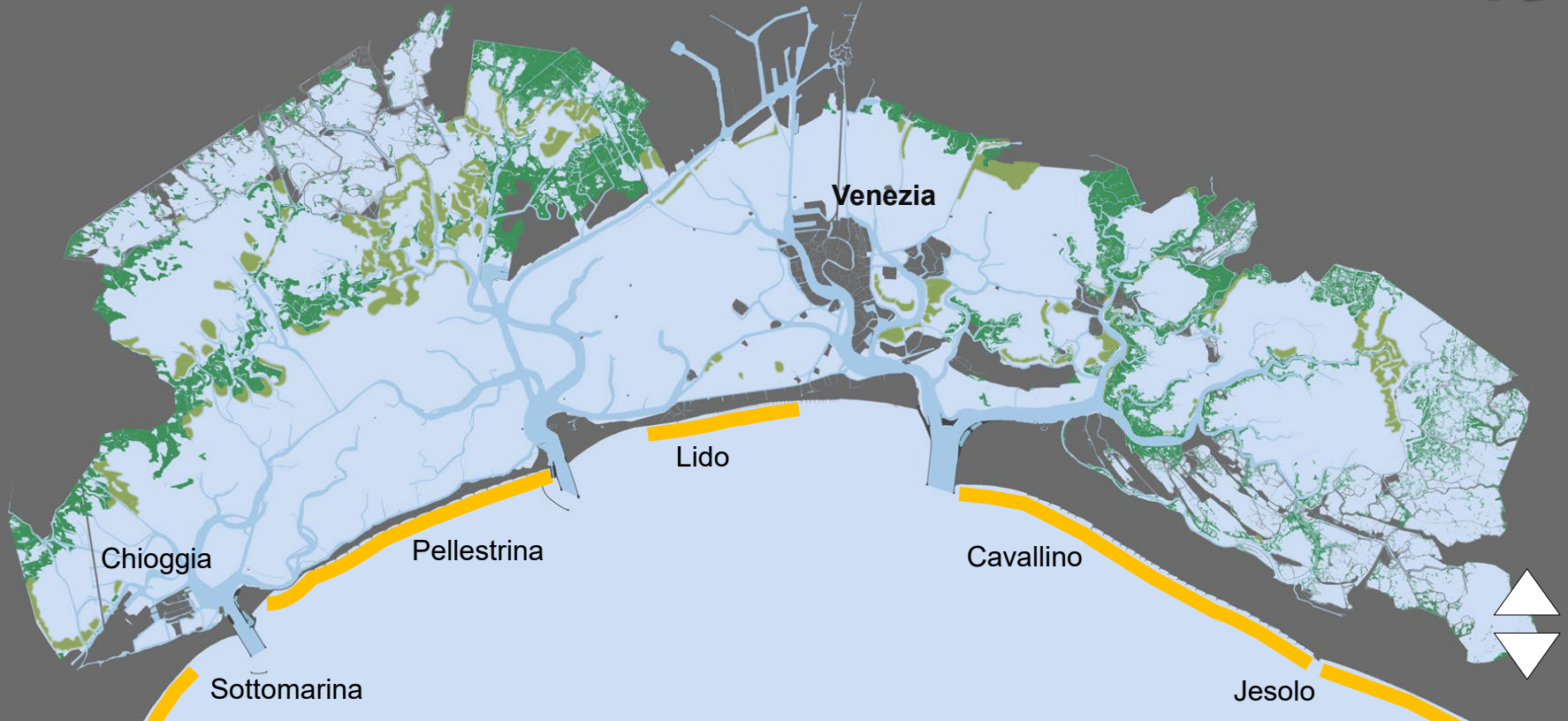


11 km
Reinforced Breakwaters

Coastal Protection

Venetian coastline(November 1966)

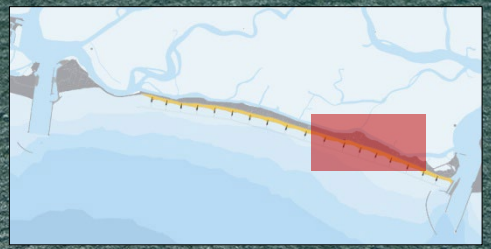
Coastal Protection



Protected Beach Nourishment

Pellestrina

Before 1999



Protected Beach Nourishment

Pellestrina

After 2000

Environmental Restoration and resilience

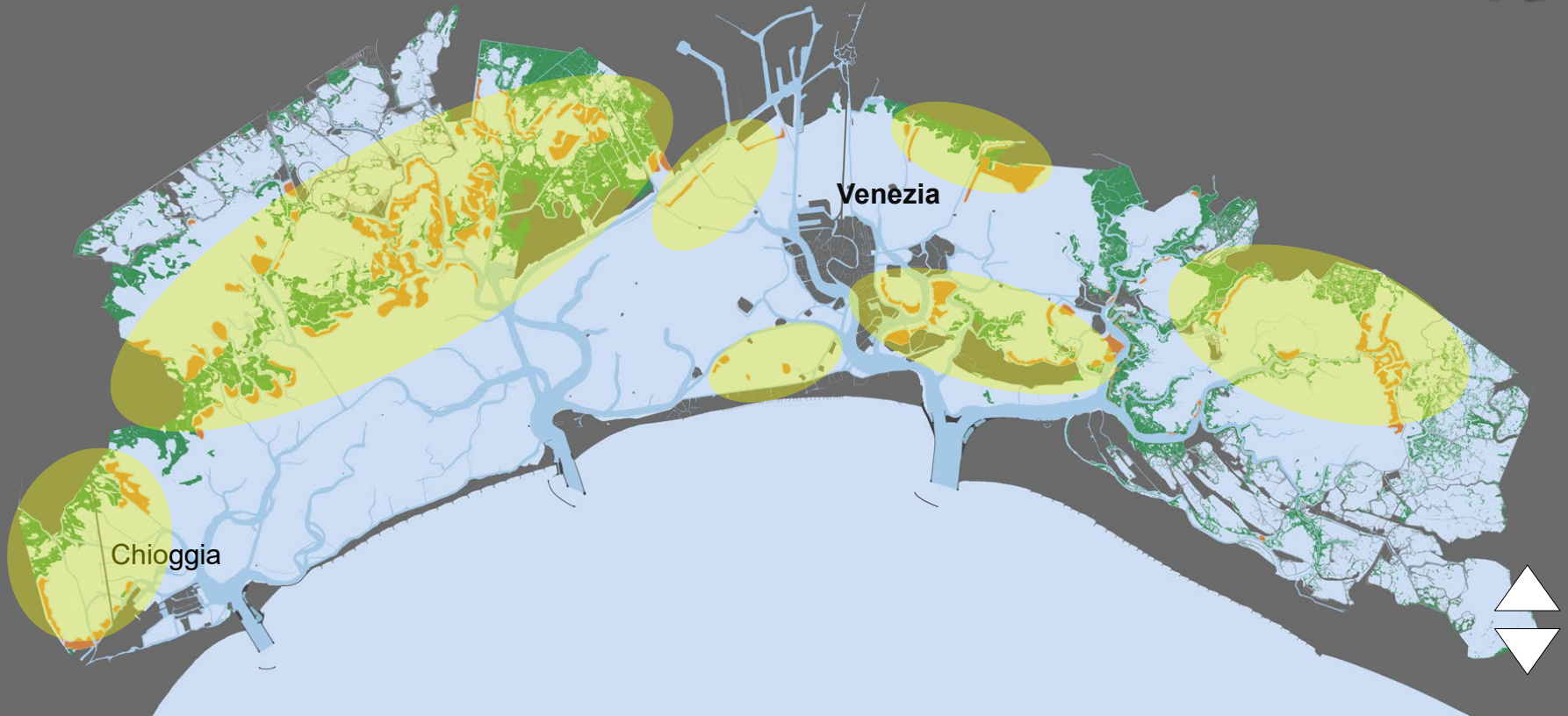
16 km^2
Constructed salt marshes

39 km
Wetland wave protection

12
Number of island restored and protected

Environmental Restoration and Resilience

Constructed salt-marshes and tidal-flats
reusing sediments from channel maintenance dredging



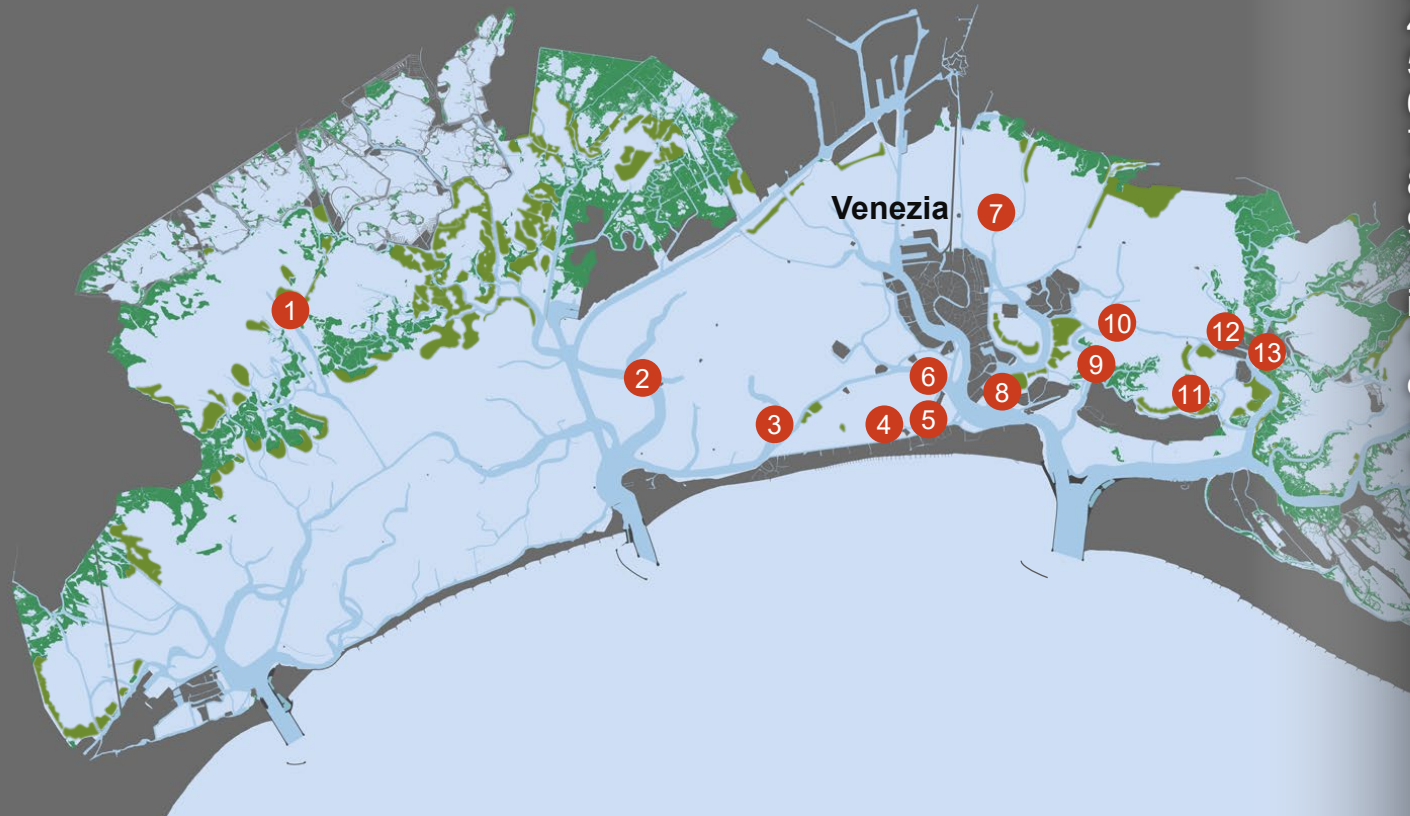
Environmental Restoration and resilience

Construction of gabion boundary
to confine pumped sediments

Environmental Restoration and resilience

Self development of alophitic plants
after 5 years

Restoration of Historical Island

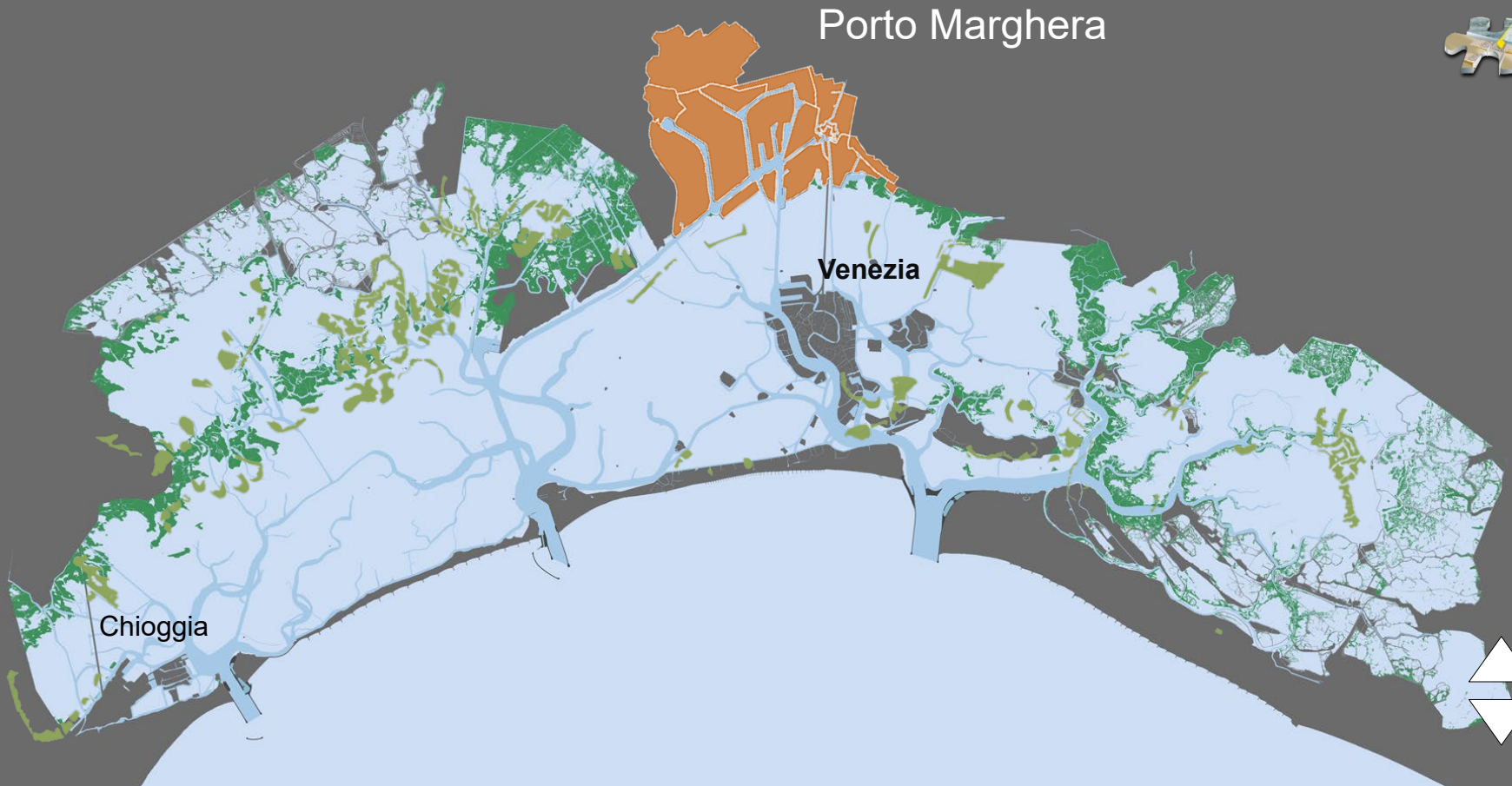


1. Motta Millecampi
2. Fisolo
3. Poveglia
4. Lazzaretto vecchio
5. Armeni
6. S. Servolo
7. Campalto
8. Certosa
9. Lazzaretto nuovo
10. S. Giacomo in paludo
11. S. Francesco del deserto
12. Laghi
13. Torcello

Poveglia Island Restoration

1. Octagon Restoration/Consolidation
2. Renovation / consolidation of masonry banks
3. Side reinforcement
4. Rehabilitation / redevelopment of the internal canal
5. Cavana renovation

Environmental Protection



Environmental Protection

Protection of dump sites

Prima dei lavori

Environmental Protection

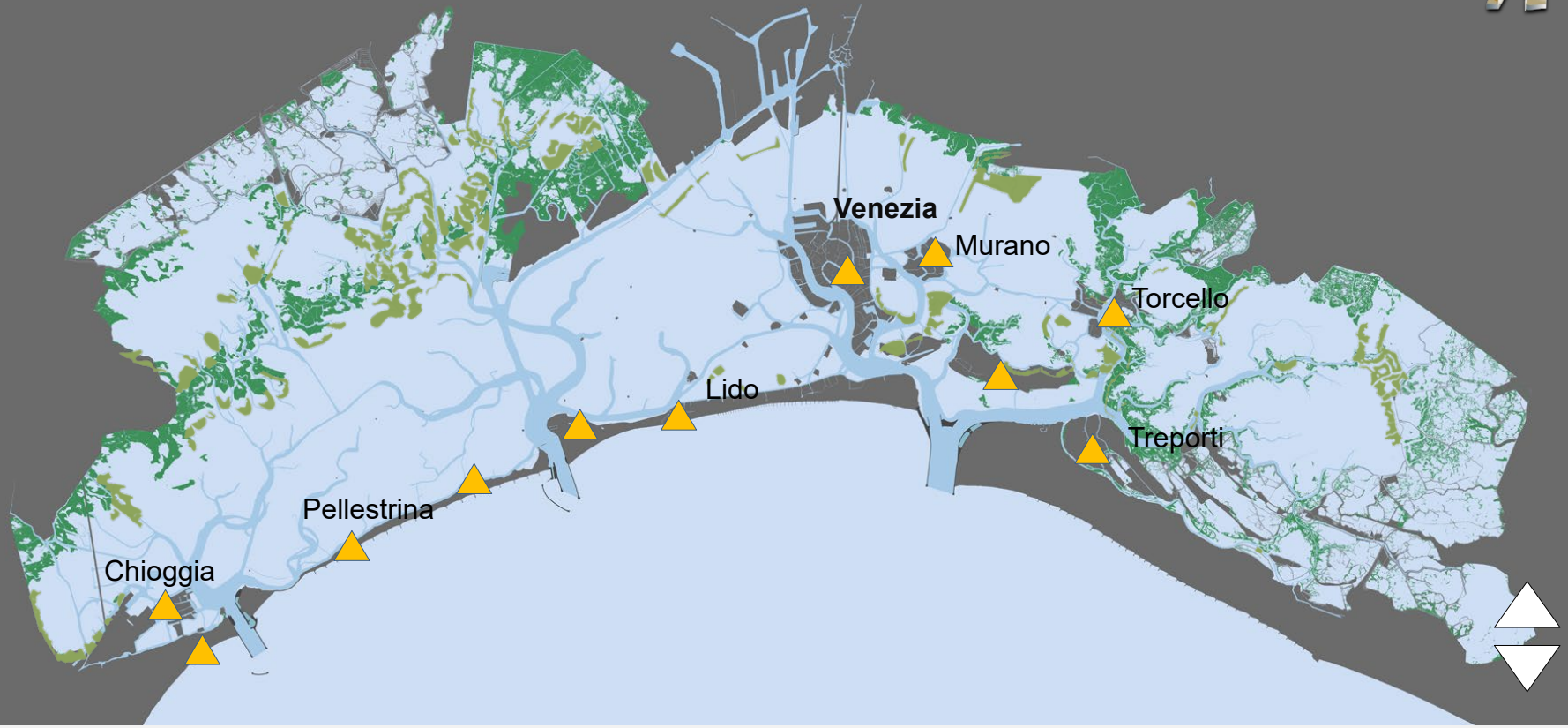
Protection of dump sites

Dopo i lavori

Urban local flood protection and restoration

100 km
Elevation and flood protctcion
of urban space

Local flood protection and restoration



Urban local flood protection and restoration

Venezia – La riva delle Zattere prima dei lavori

Urban local flood protection and restoration

Venezia – la riva delle Zattere dopo i lavori

Urban local flood protection and restoration

Chioggia, before the works

Urban local flood protection and restoration

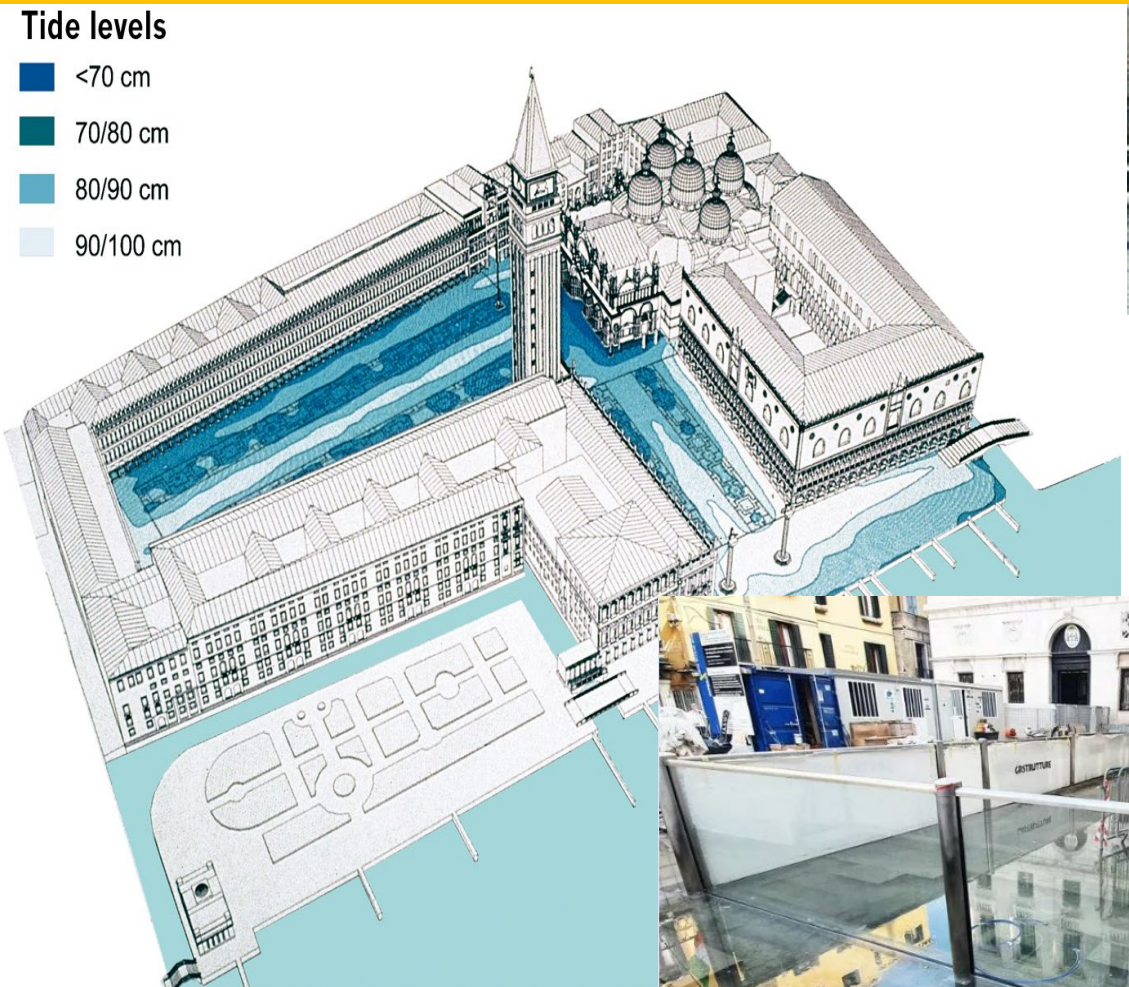
Local urbana adaptation to sea level rise

Urban local flood protection and restoration

Chioggia, Baby Mose

- Chioggia Mini Mose

Piazza San Marco problems and first interventions



Overtopping

Back-flow

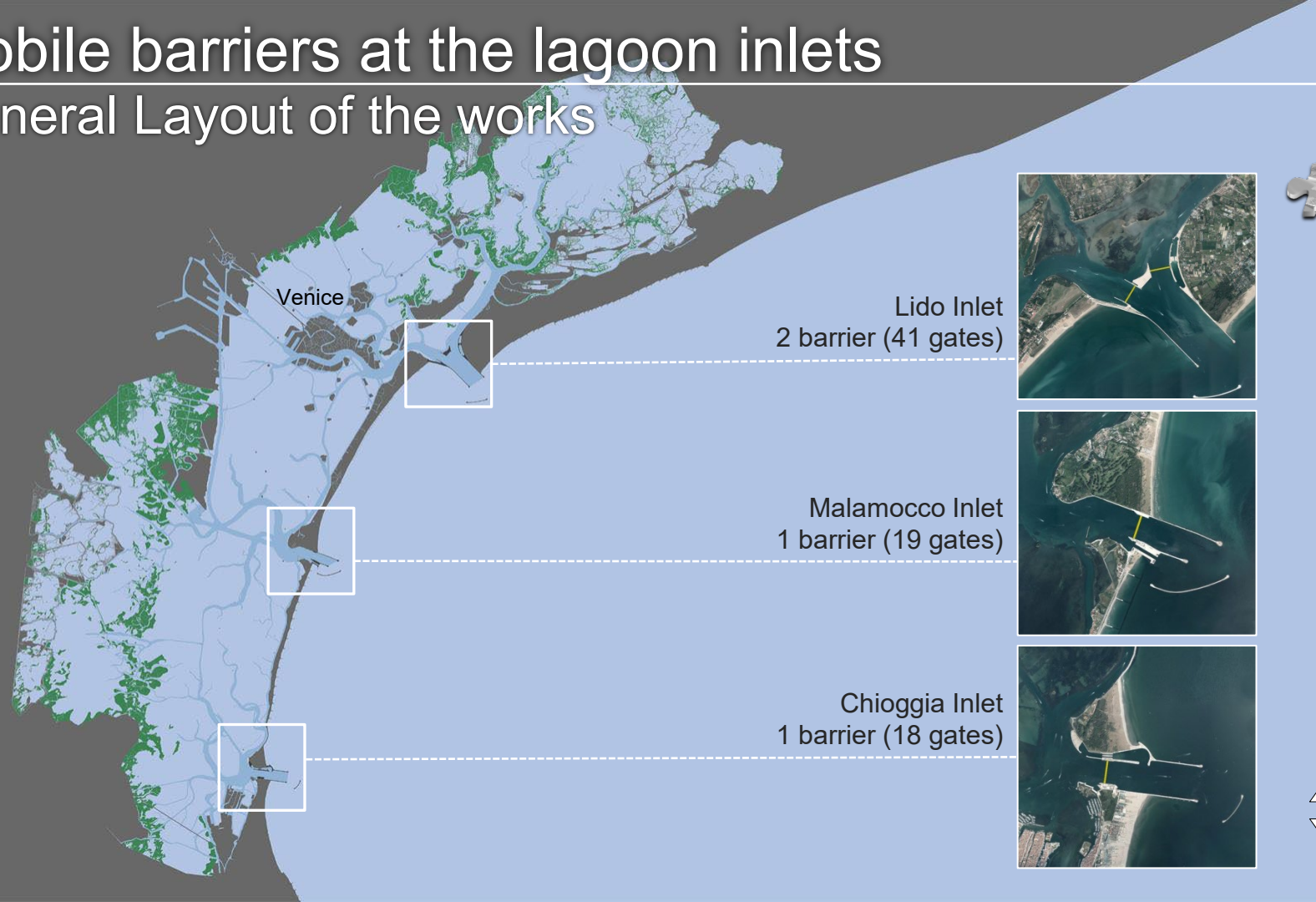
Seepage

Glass Barriers


Le barriere mobili
per la difesa
dalle acque alte

Mobile barriers at the lagoon inlets

General Layout of the works



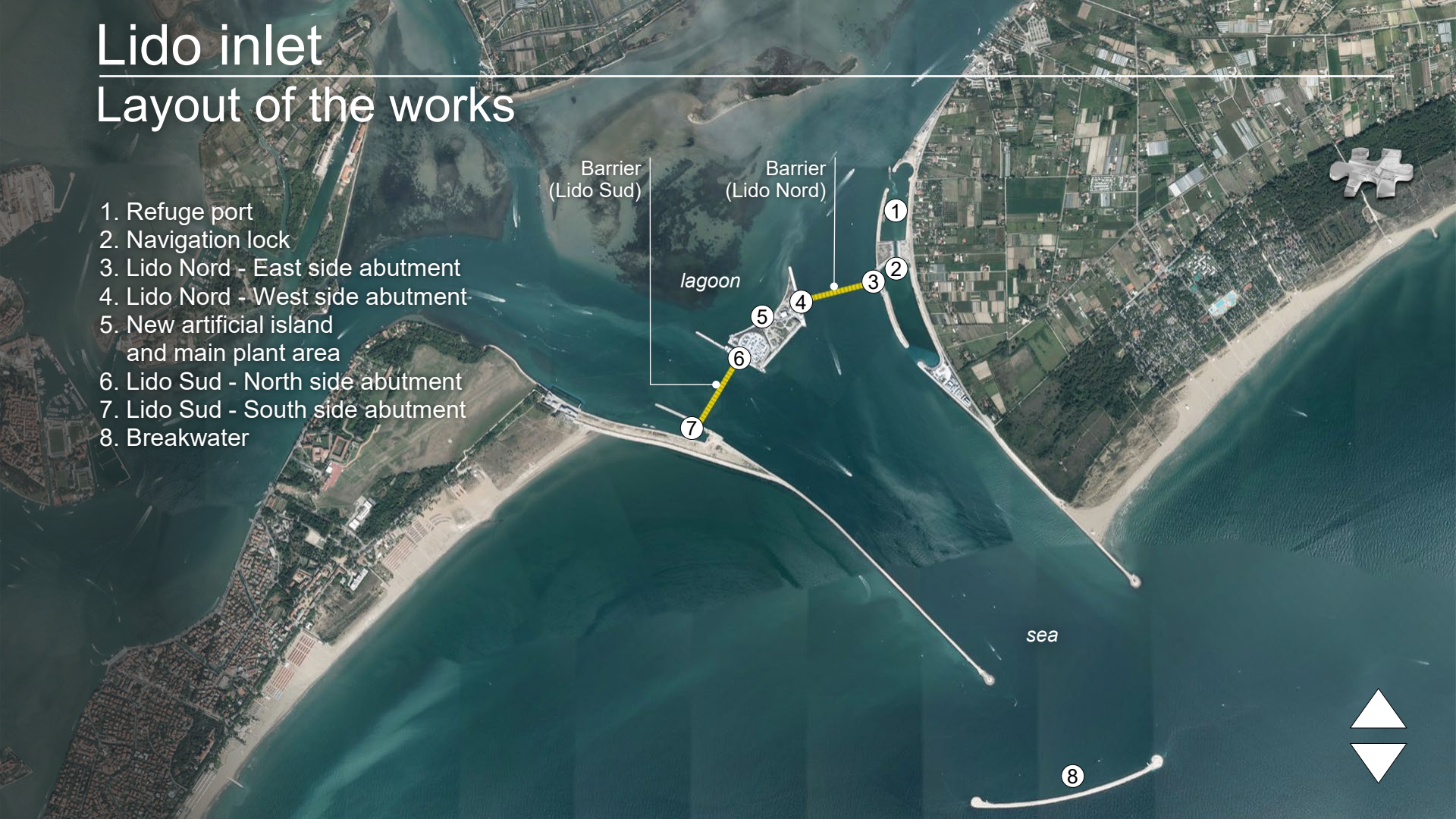
Lido Inlet
2 barrier (41 gates)

Malamocco Inlet
1 barrier (19 gates)

Chioggia Inlet
1 barrier (18 gates)

Lido inlet

Layout of the works



1. Refuge port
2. Navigation lock
3. Lido Nord - East side abutment
4. Lido Nord - West side abutment
5. New artificial island
   and main plant area
6. Lido Sud - North side abutment
7. Lido Sud - South side abutment
8. Breakwater

Malamocco inlet

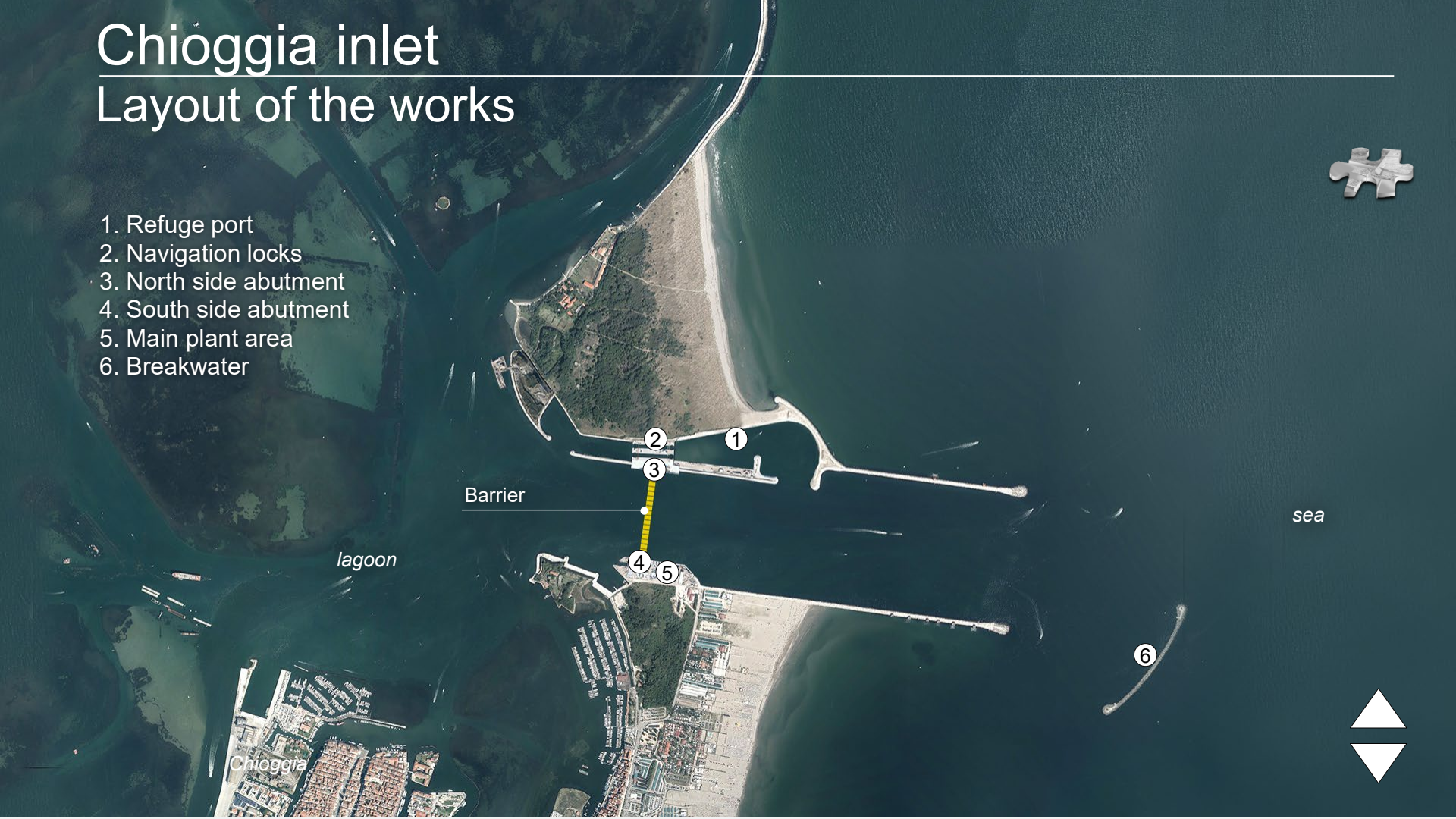
Layout of the works

1. North side abutment
2. South side abutment and main plant area
3. Navigation lock
4. Temporary work area
5. Breakwater

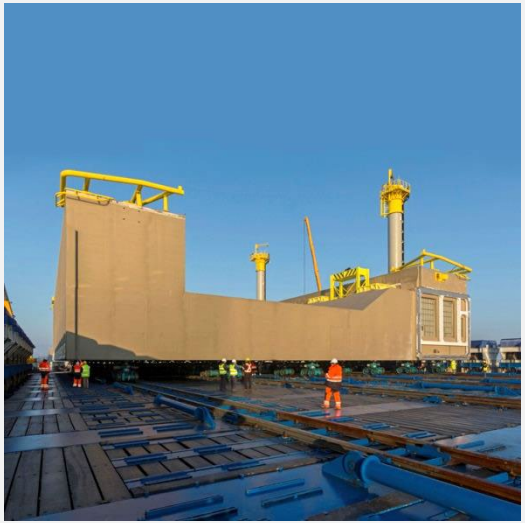
Chioggia inlet

Layout of the works

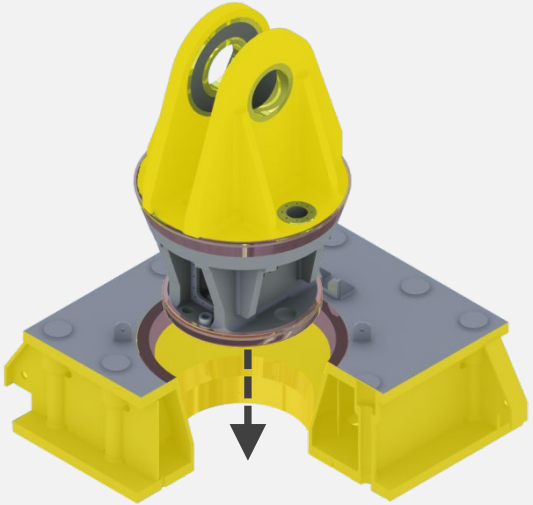
1. Refuge port
2. Navigation locks
3. North side abutment
4. South side abutment
5. Main plant area
6. Breakwater



Main components of the system



Gate housing caisson
and abutment caisson

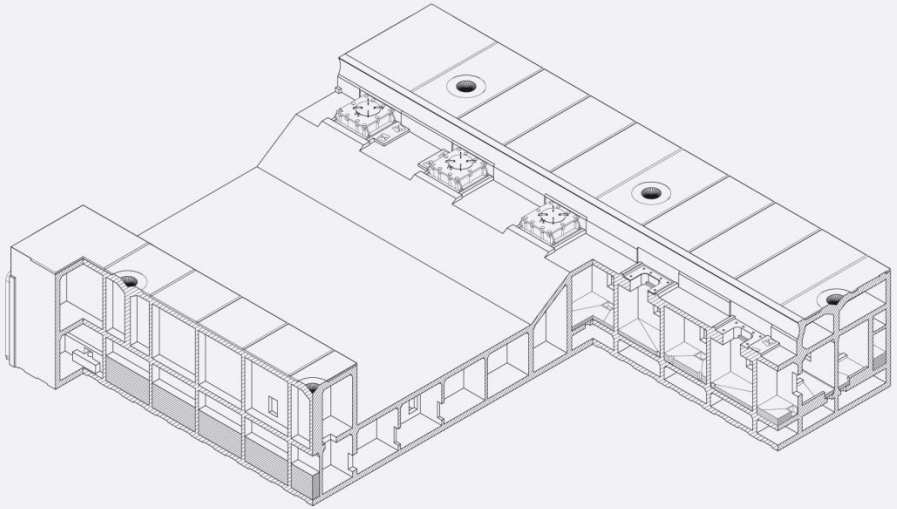


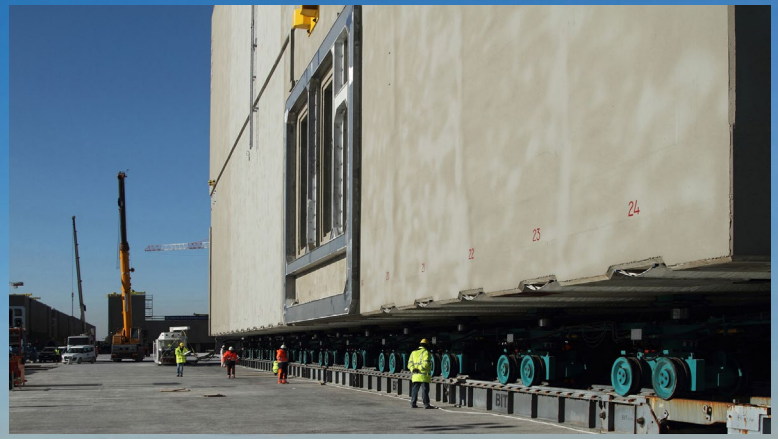
Hinges

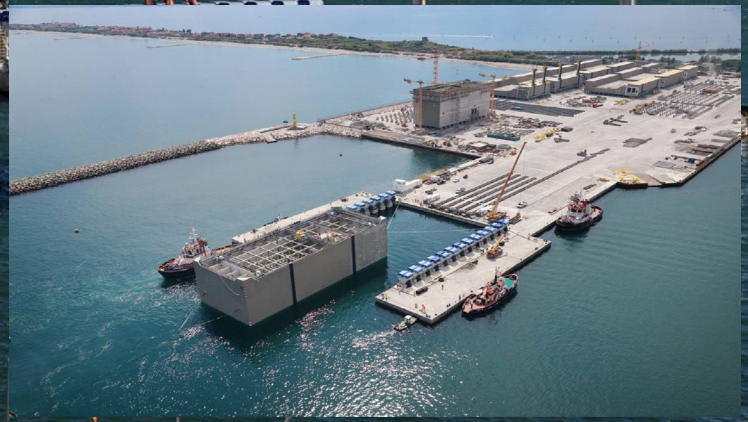
Floodgates

Main components of the system

Gate housing caissons







Main components of the system

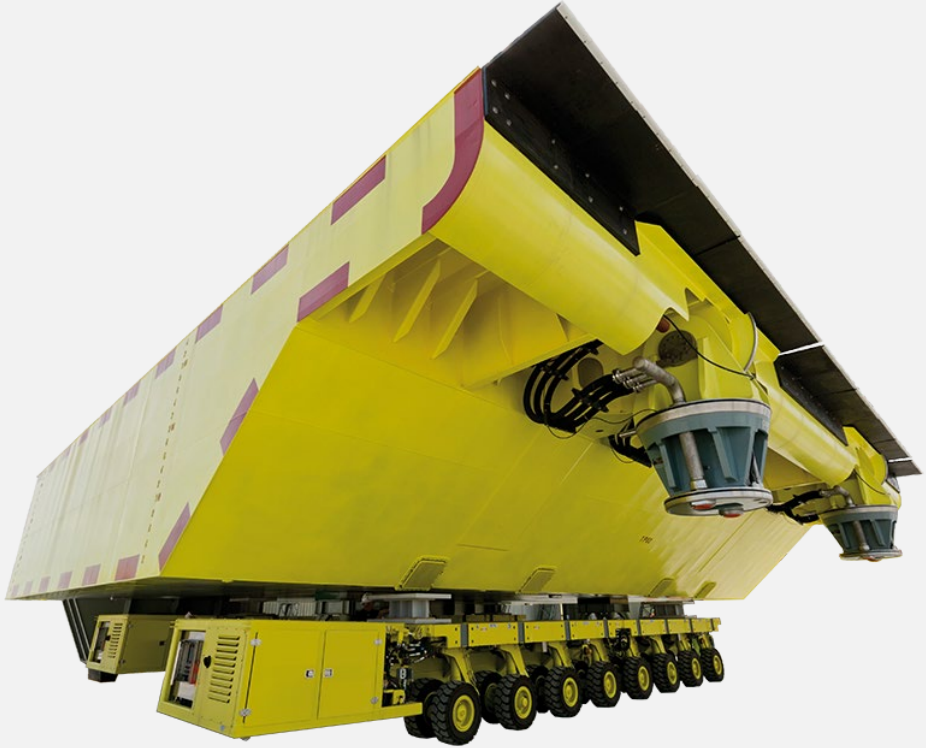
Gate housing caissons. Construction

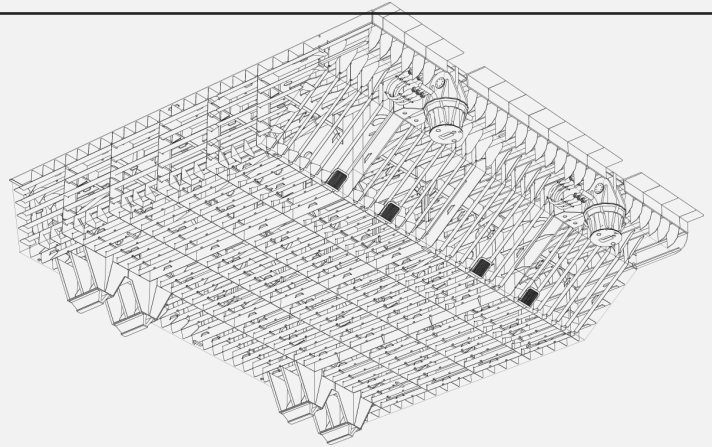
Malamocco

Gate housing caissons:
w. **59 m** / l. **48 m** / h. **11,5 m**

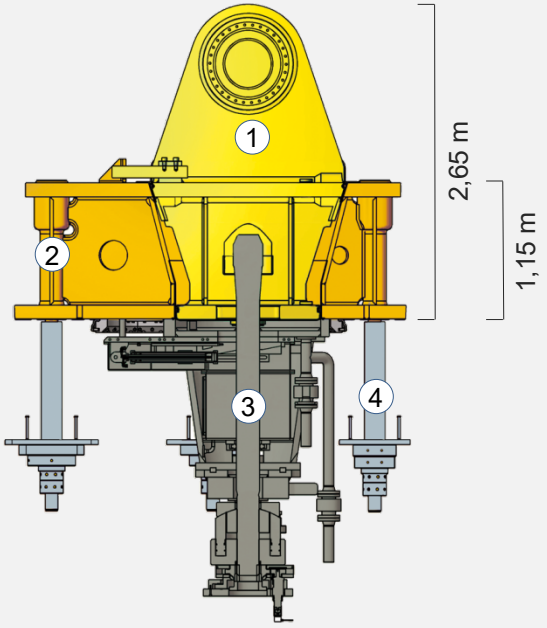
Abutment caissons:
w. **24 m** / l. **63 m** / h. **28 m**

THE SINGLE FLAP GATE

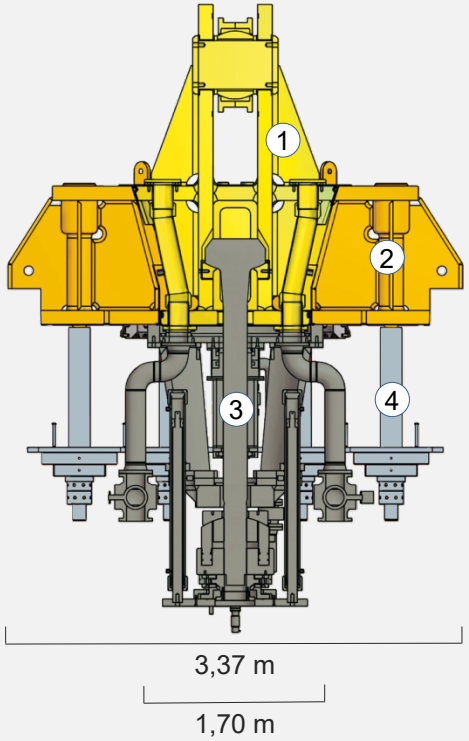




Hinge Coupling Assembly



Cross-section



Longitudinal section

1. Male Element
   (hooked to the gate)
2. Female Element
   (fixed on the top surface
   of the housing body)
3. Coupling unit
   (for the connection between
   male and female)
4. Anchor bars
   (for fixing the female
   to the housing body
   of the sluice gates)

Main components of the system

Floodgates. Installation

Lido sud barrier

Electromechanical systems

Main plants

Pneumatic system (process air)
Compressor cooling water system
Electrical system and generators
Control System

Auxiliary systems

HVAC (ventilation and air conditioning)
Flushing system (washing lines and hinges)
Diesel system (serving the generators)
Special fire extinguishing systems
Fire detection and extinguishing
Ancillary systems

The new island for plant at Lido inlet

Lido Treporti construction *(2008)*

Construction site set-up
and start of construction of structures

Lido Treporti construction *(2012)*

Lido North

Sluice gate foundations:
Width. 60 m / length 36 m /
H. 8.7 m / Weight 13,000 tn

Shoulder elements:
Width. 23.8 m / length 49 m /
H. 16.7 m / Weight 9,000 tn

Lido South

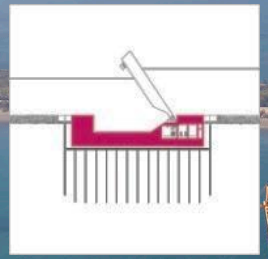
Sluice gate foundations:
Width. 60 m / length 45.5 m /
H. 11 m / Weight 19,500 tn

Shoulder elements:
Width. 24 m / length 60 m /
H. 25 m / Weight 15,000 tn

Lido Treporti construction *(May September 2012)*

Launch of structures

Malamocco Caissons Construction June 2014



Malamocco

Sluice gate foundations:
Width. 60 m / length 48.3 m /
height 11.5 m / weight

22,500 tn Shoulder Elements:
Width. 24 m / length 63 m /
H. 28 m / Weight 17,400 tn

Immersed Tunnel and
Abutment Caisson
Construction

Caisson launching platform

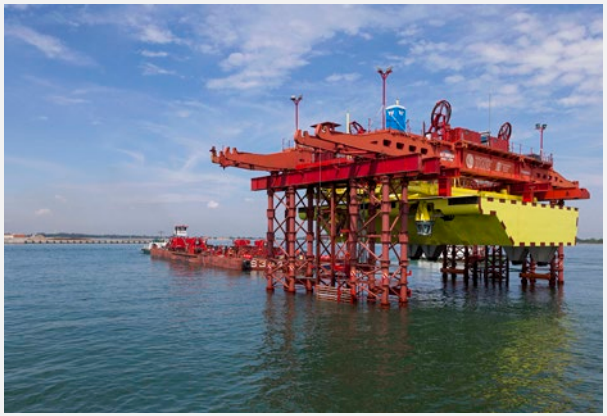
(Syncrolift)

Pneumatic Rail Transport of Verical Abutment Caisson

Transport of an Immersed Tunnel Caisson
June-October 2014

Caissons and gates installation

Installation
of the caissons
(immersed tunnel
elements)

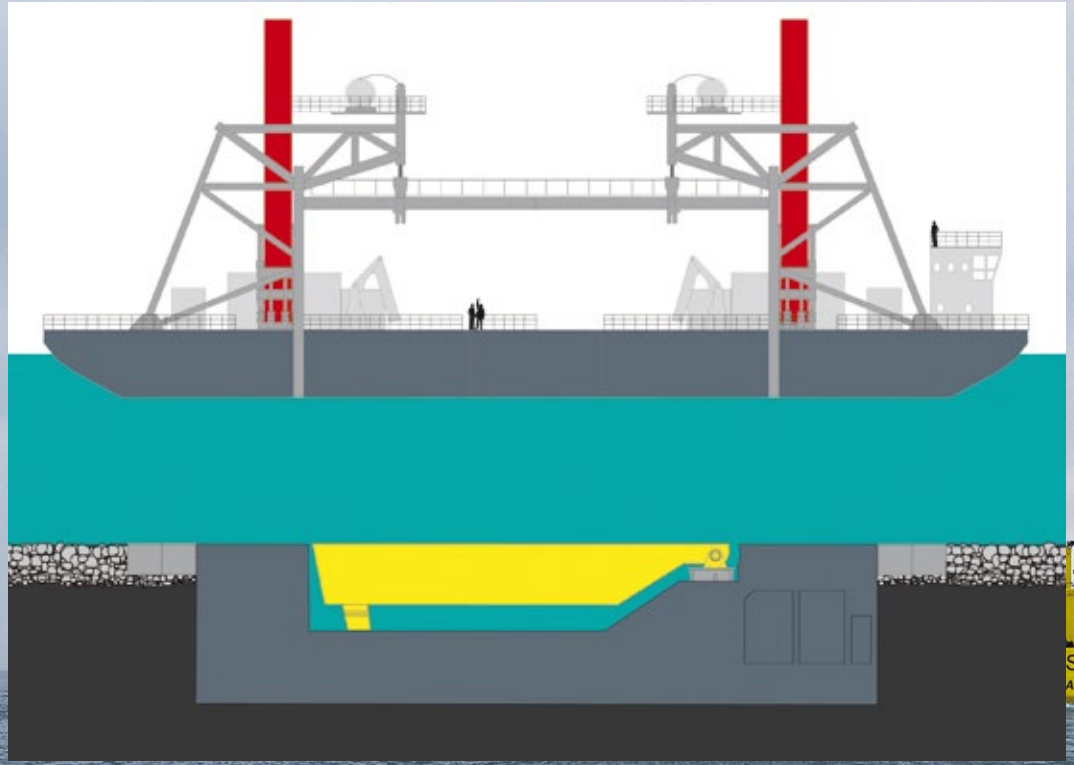


Installation
& Handling
of the flap gates
of the barriers
of Lido Nord
and Malamocco

Gates Installation Temporary Crane

Gates Installation Jack-up barge

The "jack up" for handling the gates



MO.S.E. as a flexible system

- The DSS for operating MOSE was developed and tested since 1992, before the work stated to be operated in order to achieve a very high probability of success

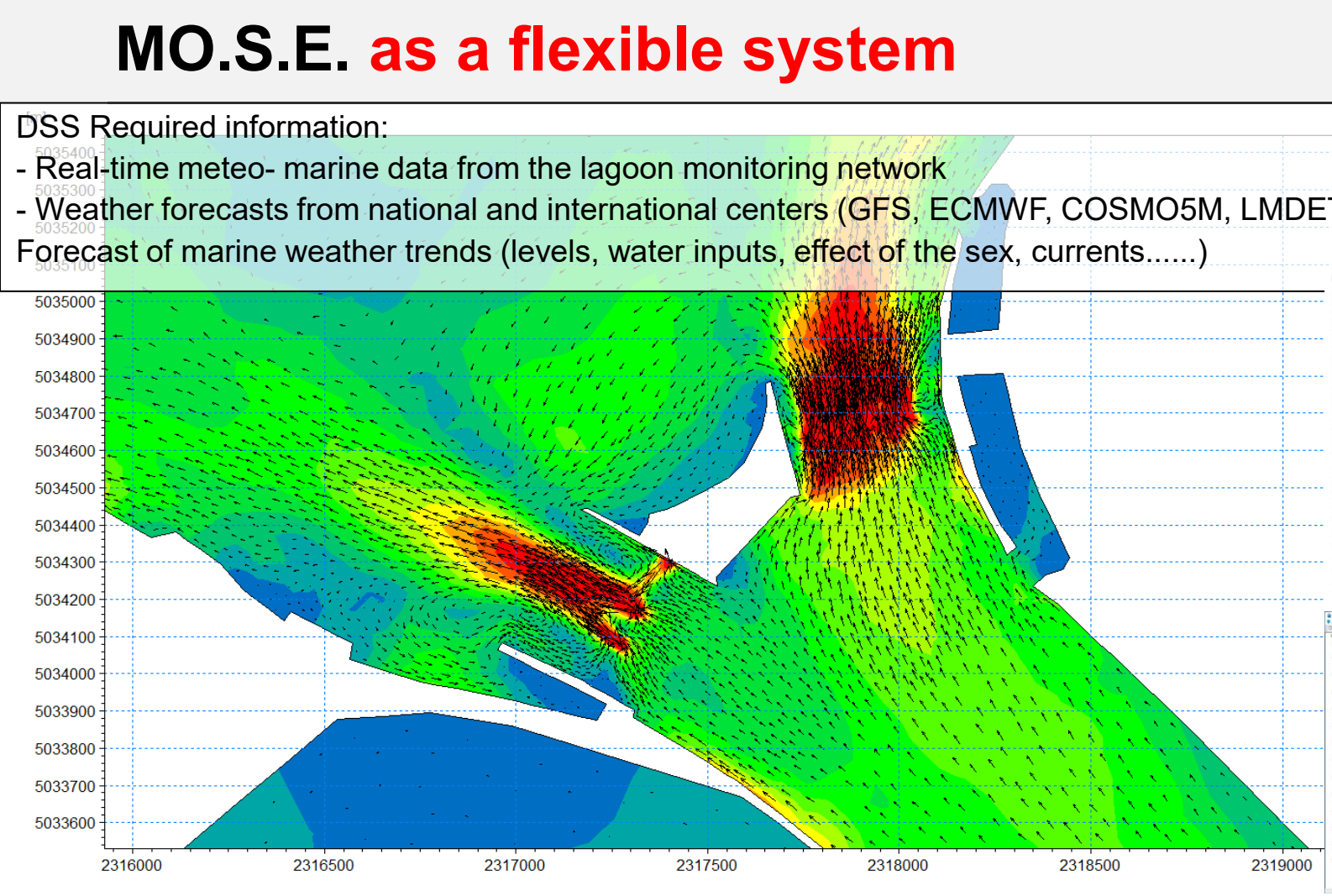
- Complementary operations for settling comples social and environmental interactions has been envisaged

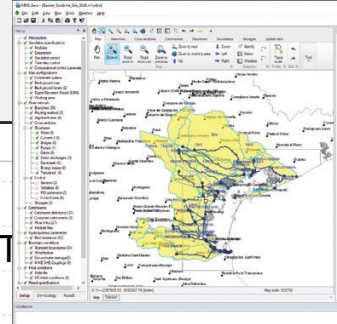
MO.S.E. as a flexible system

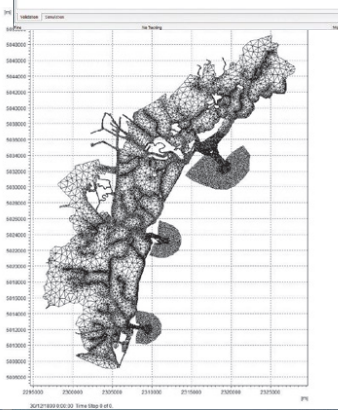
DSS Required information:

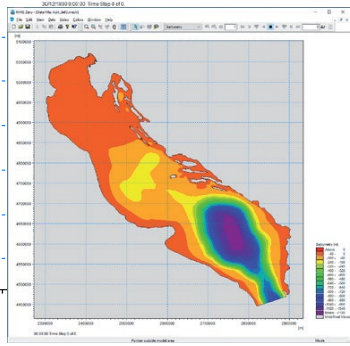
- Real-time meteo- marine data from the lagoon monitoring network
- Weather forecasts from national and international centers (GFS, ECMWF, COSMO5M, LMDET

Forecast of marine weather trends (levels, water inputs, effect of the sex, currents.....)

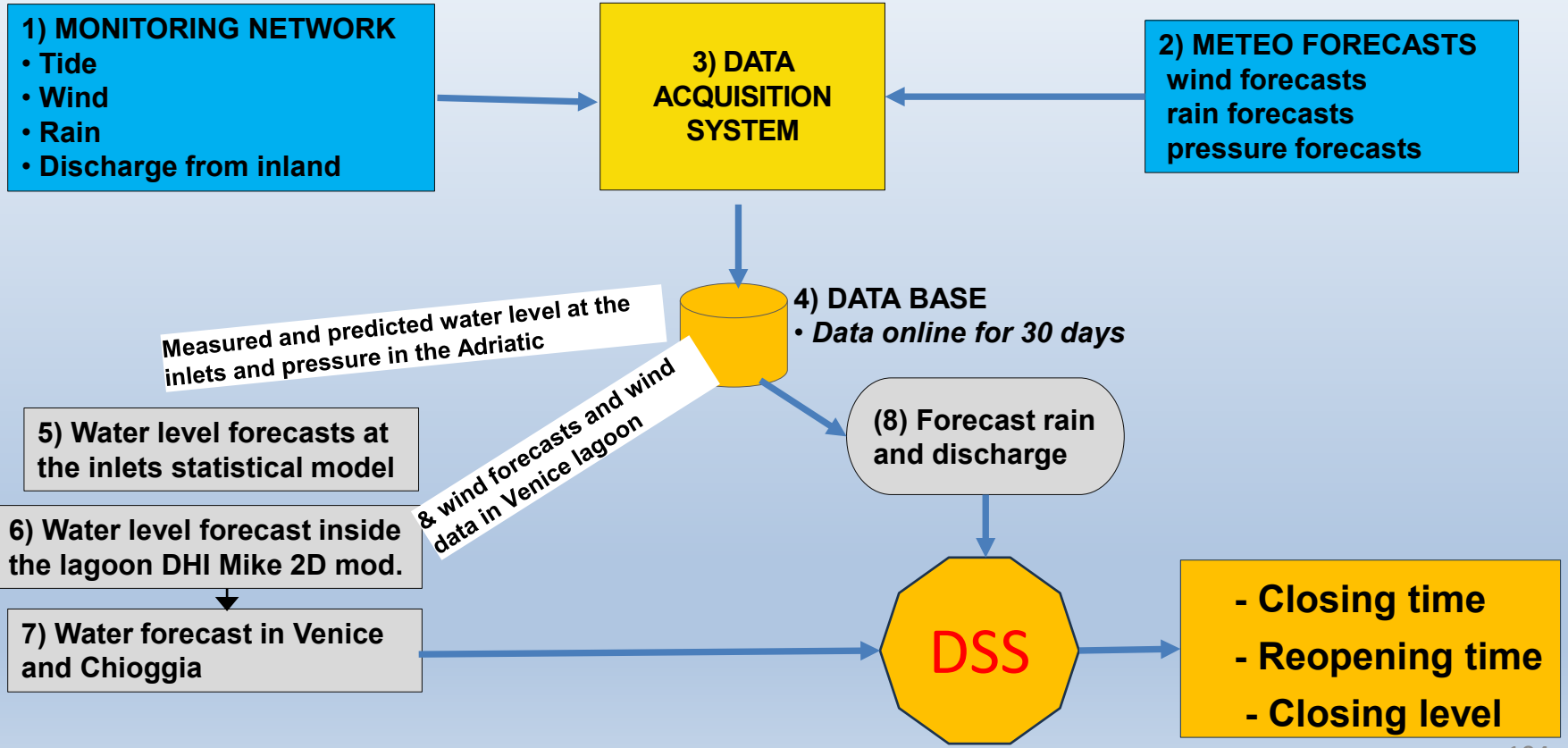


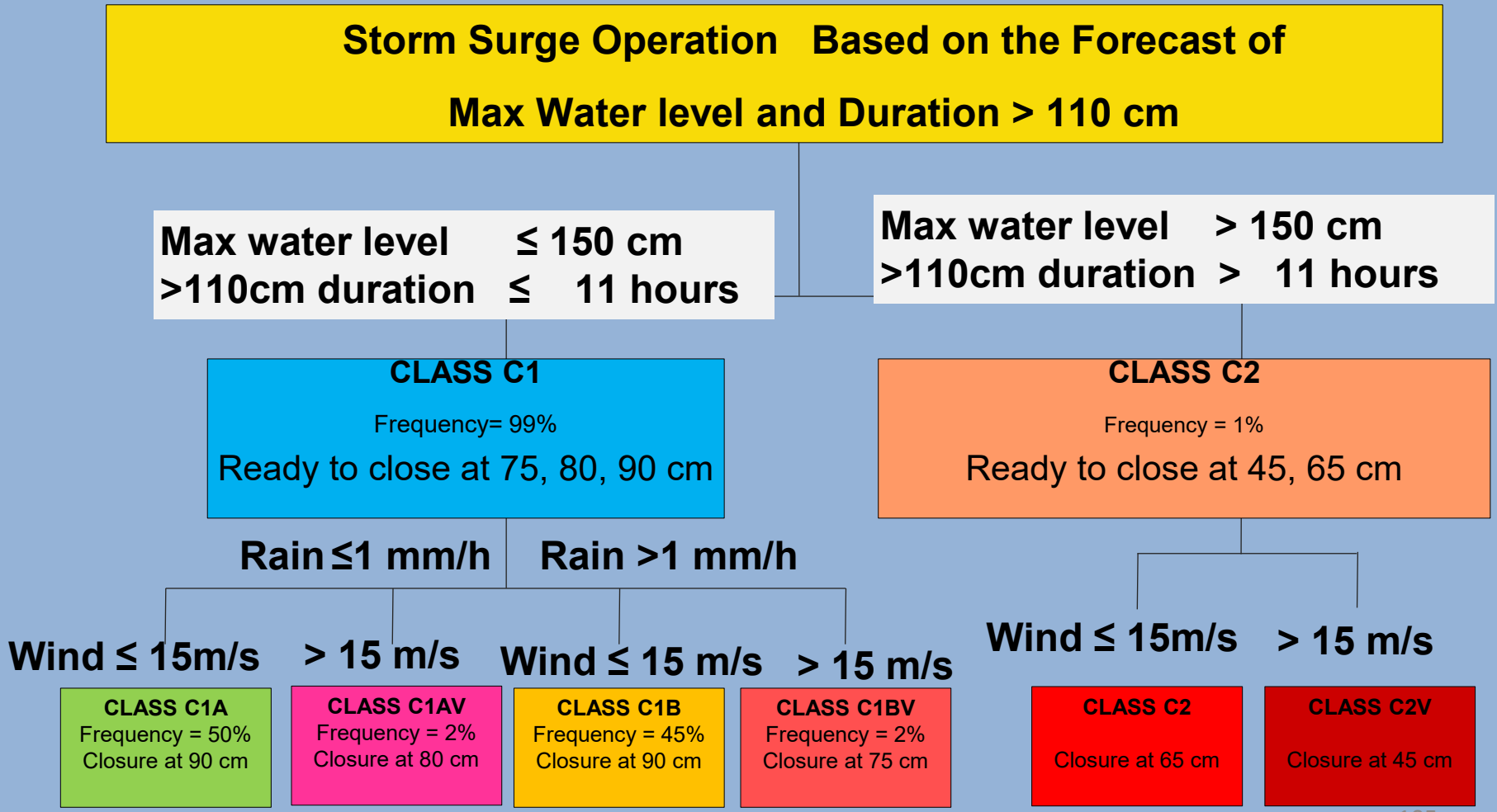






MO.S.E. as a flexible system




Storm Surge Operation Based on the Forecast of
Max Water level and Duration > 110 cm
Max water level ≤ 150 cm
>110cm duration ≤ 11 hours
Max water level > 150 cm
>110cm duration > 11 hours
CLASS C1
Frequency= 99%
Ready to close at 75, 80, 90 cm
CLASS C2
Frequency = 1%
Ready to close at 45, 65 cm
Rain ≤1 mm/h
Rain >1 mm/h
Wind ≤ 15m/s
> 15 m/s
Wind ≤ 15 m/s
> 15 m/s
Wind ≤ 15m/s
> 15 m/s
CLASS C1A
Frequency = 50%
Closure at 90 cm
CLASS C1AV
Frequency = 2%
Closure at 80 cm
CLASS C1B
Frequency = 45%
Closure at 90 cm
CLASS C1BV
Frequency = 2%
Closure at 75 cm
CLASS C2
Closure at 65 cm
CLASS C2V
Closure at 45 cm

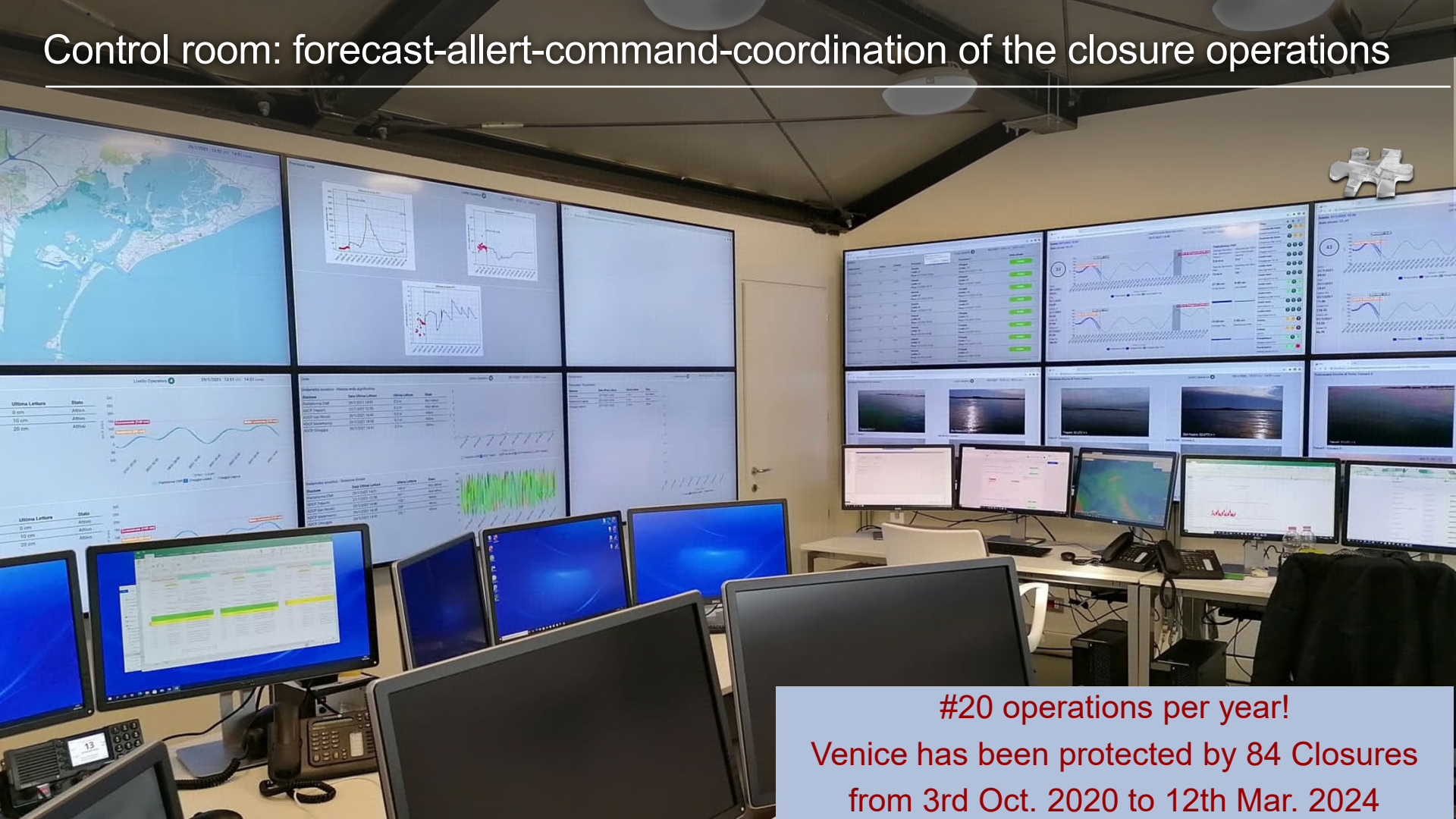
Lido Controll Room

Lido Closure

Malamocco Closure

Chioggia Closure

Control room: forecast-allert-command-coordination of the closure operations



#20 operations per year!

Venice has been protected by 84 Closures

from 3rd Oct. 2020 to 12th Mar. 2024


1. Jack up Wharf
2. Gates washdown area
3. New building for gate maintenance
4. Technical Services Building
5. Gate Storage Area
Venice Arsenal
1
2
3
4
5
Cleaning
Paint Stripping (hydroblasting)
Paint Stripping (sand blasting)
Painting

Removal of the first sluice gate of the Treporti barrier

On July 5, 2023, the first sluice gate of the Lido Treporti barrier was removed after 10 years from its installation

State of the first installed sluice gate at the Treporti barrier

Flap gate after the removal of fouling
Steel surface and hinges
in excellent state of preservation

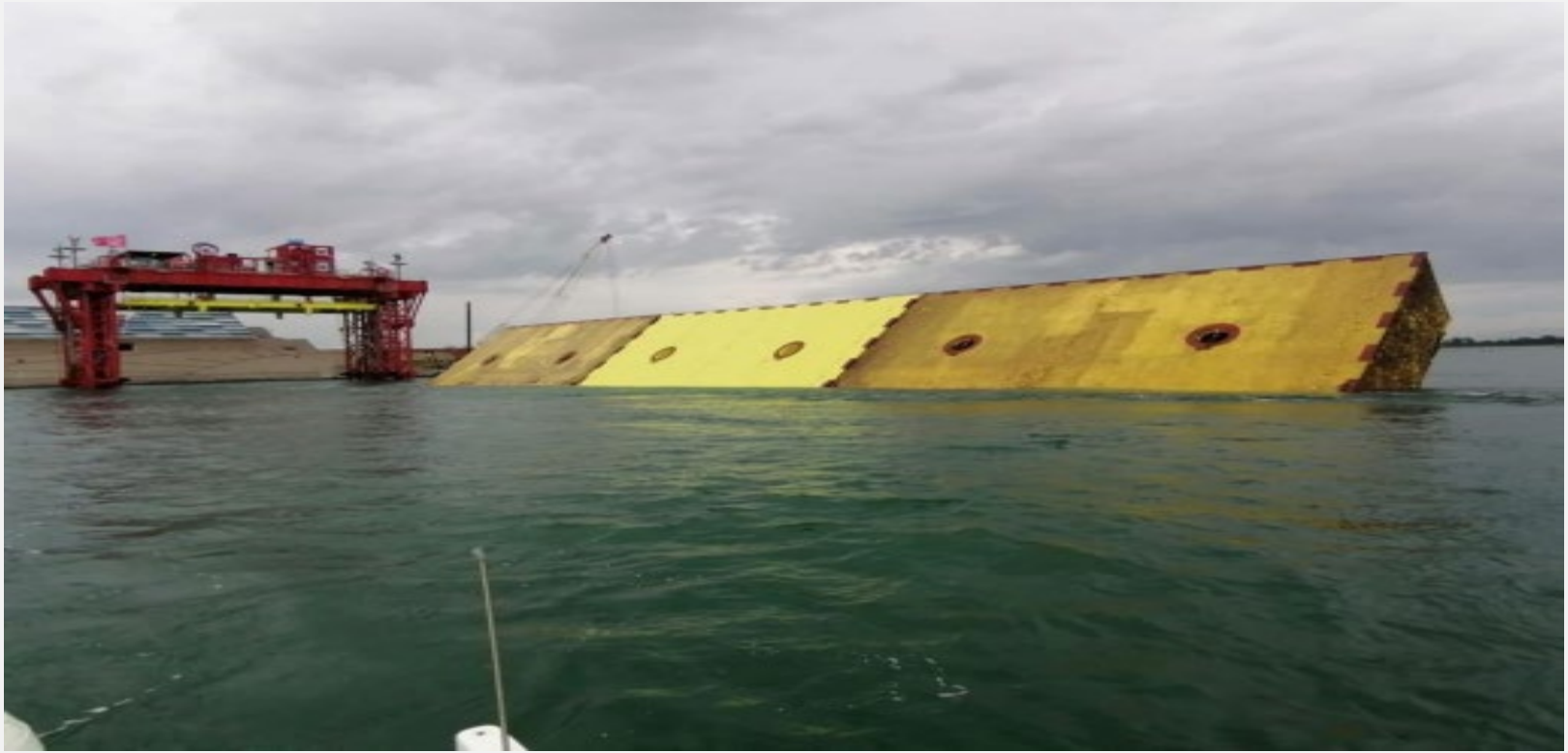
State of the first installed sluice gate at the Treporti barrier after 10 year in place underwater

Dumpers

Catodic Anod

Inner surface

Installation of the spare gate at Treporti

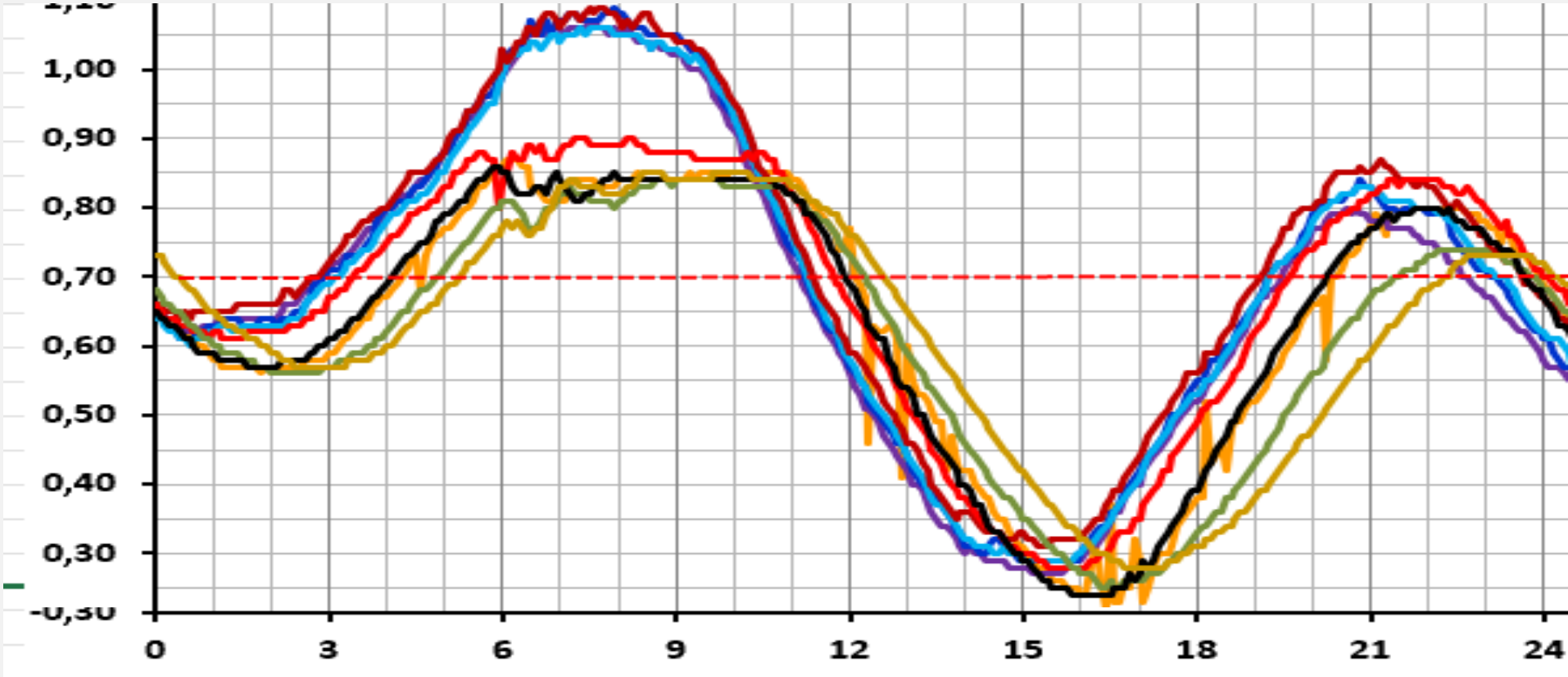


Lessons about maintenance

0. Increase the speed of maintenance due to sea level rise
1. Need for multiple replacement sluice gates
2. Increased service interval
3. Possible use of different materials
4. Refinement of the command and control system
5. Digitalization of the system
6. Review of engagement procedures (efficiency/effectiveness)

#20 operations per year!

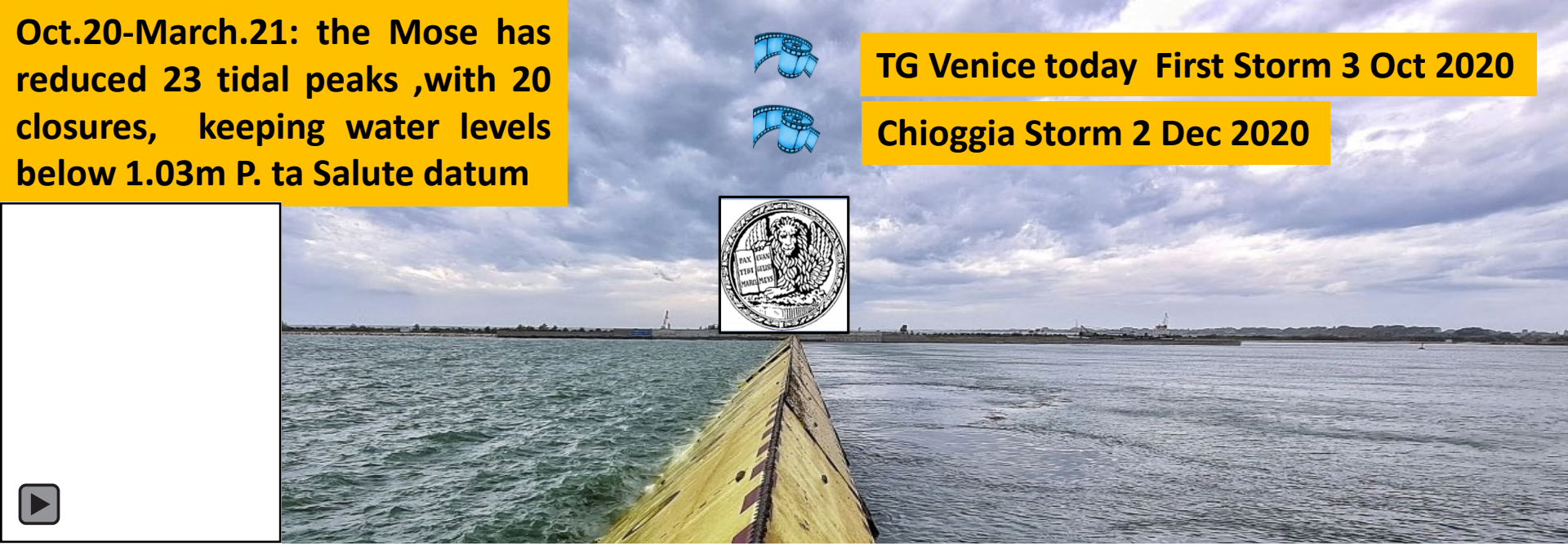
Venice has been protected by 84 Closures from 3rd Oct. 2020 to 12th March 2024

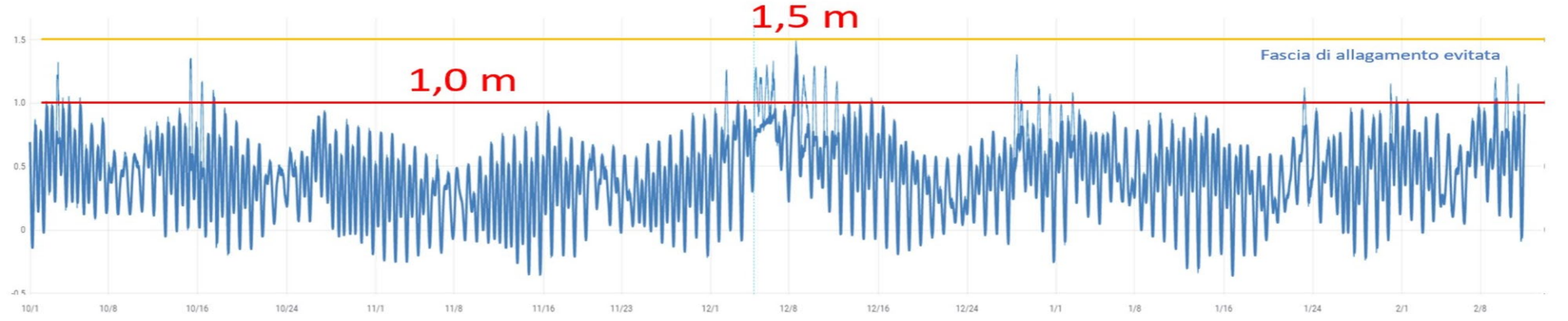


Oct.20-March.21: the Mose has reduced 23 tidal peaks ,with 20 closures, keeping water levels below 1.03m P. ta Salute datum

TG Venice today First Storm 3 Oct 2020

Chioggia Storm 2 Dec 2020



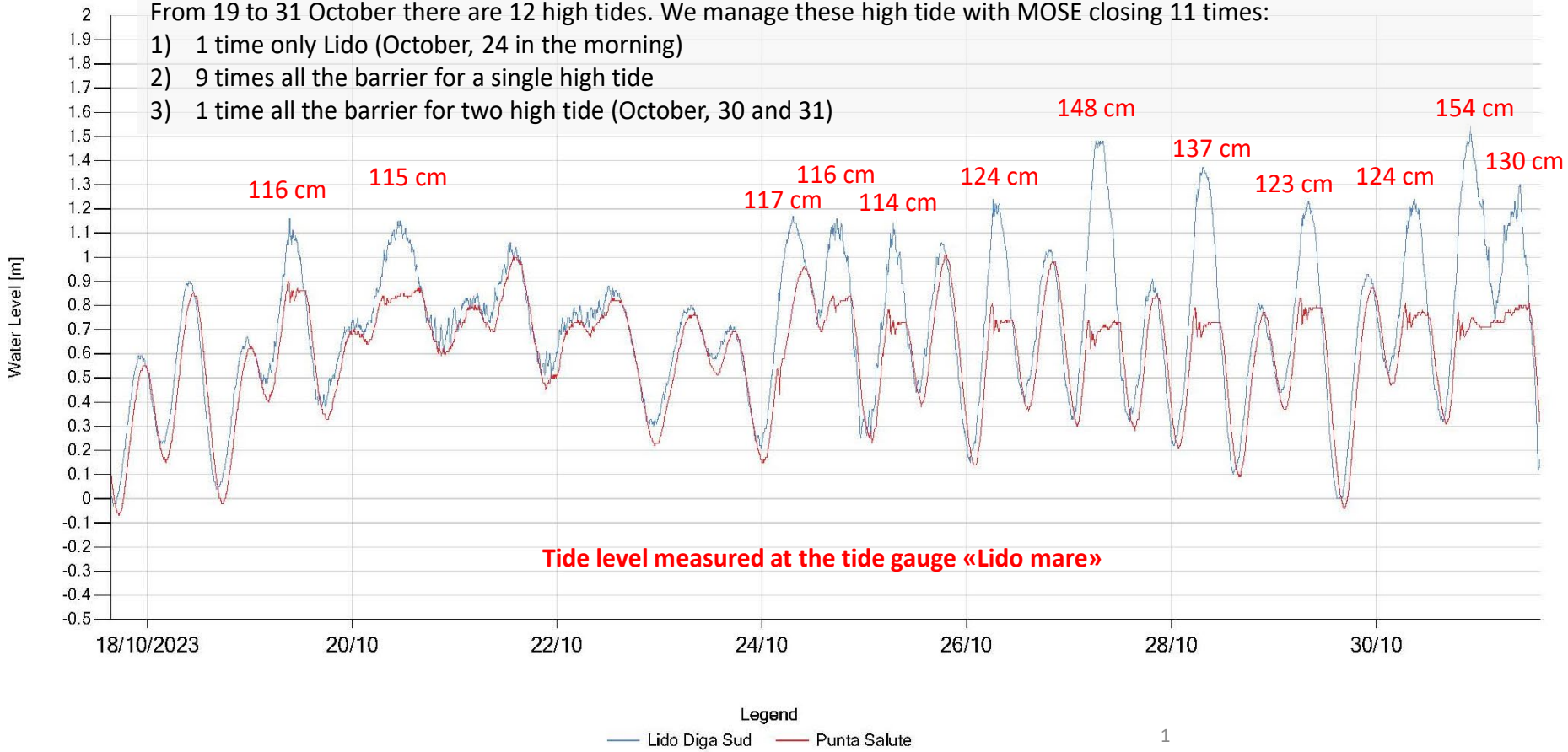


MO.S.E. OCTOBER 2023

On November 22, 2022, the third worst storm surge of 2.0m was kept out of the lagoon

From 19 to 31 October there are 12 high tides. We manage these high tide with MOSE closing 11 times:

1) 1 time only Lido (October, 24 in the morning)
2) 9 times all the barrier for a single high tide
3) 1 time all the barrier for two high tide (October, 30 and 31)



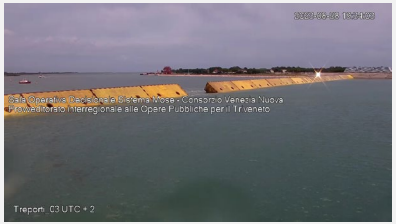
MO.S.E. as a flexible system

General Strategy

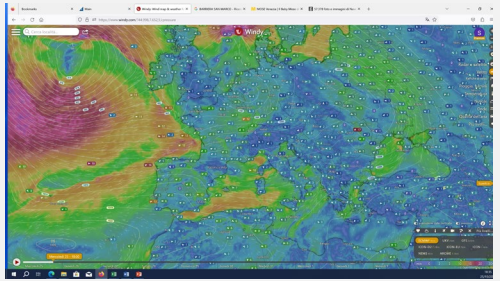
SHIP DELAYS
PORT AUTHORITY'S
OPERATIONAL NEEDS

LOCAL PROTECTIONS
BABY MOSE IN CHIOGGIA
AND
ST. MARK'S

PLANTS
POSSIBLE SYSTEM
PROBLEMS



METEO MARINE MARINE DATA
AND FORECASTS



MO.S.E. as a flexible system

Differential Operations of the MOSE System

1. On/Off closures and partial closures of one or more barriers or subset of flaps in each a barrier

1. Water quality and sediment/wetland issues

MO.S.E. as a flexible system

On/Off Use:

- A single closure
- More closures to deal with particular weather situations
- Modulated closures (Need to close/reopen Chioggia and/or Malamocco for special navigational needs)
- Partial closure (only Lido) to reduce the impact on navigation and induce tidal flushing

MO.S.E. as a flexible system

Water quality and sediment/wetland issues and nesting

Preventing pollution

Easy the collection spillage of pollutants in the lagoon

or prevente inputs from the sea or rivers

Environmental Use

Induce tidal flushing against anoxia

Reduce sediment loss from tidal flats to channels and sea

Facilitate Wetland starting process

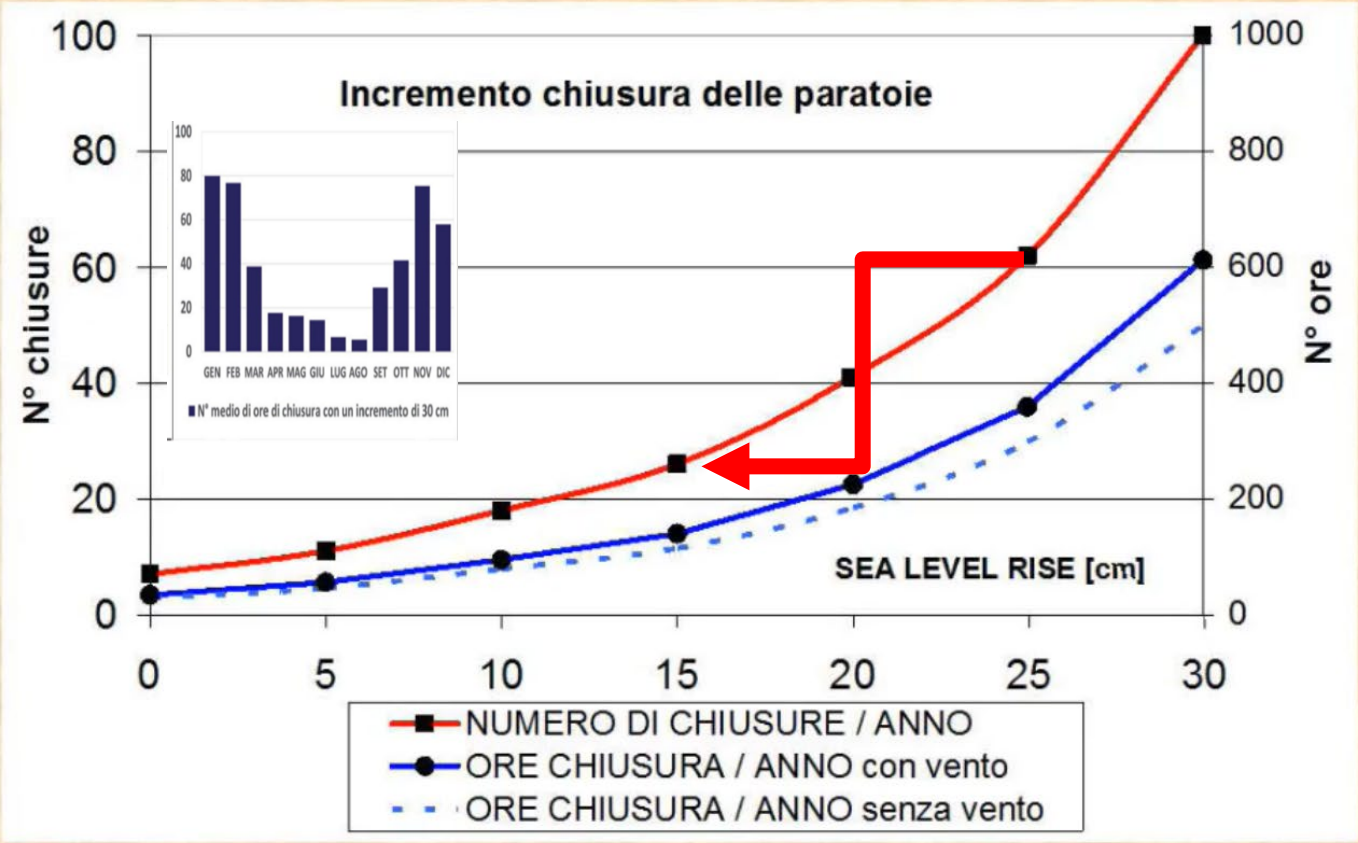
Bird nesting and reproduction

Unexpected new island induced by the Mose closures limiting winter shoal overtopping

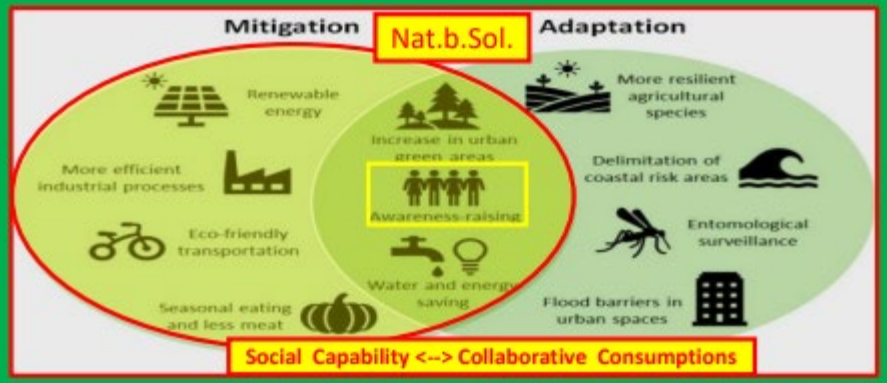
Concluding remarks

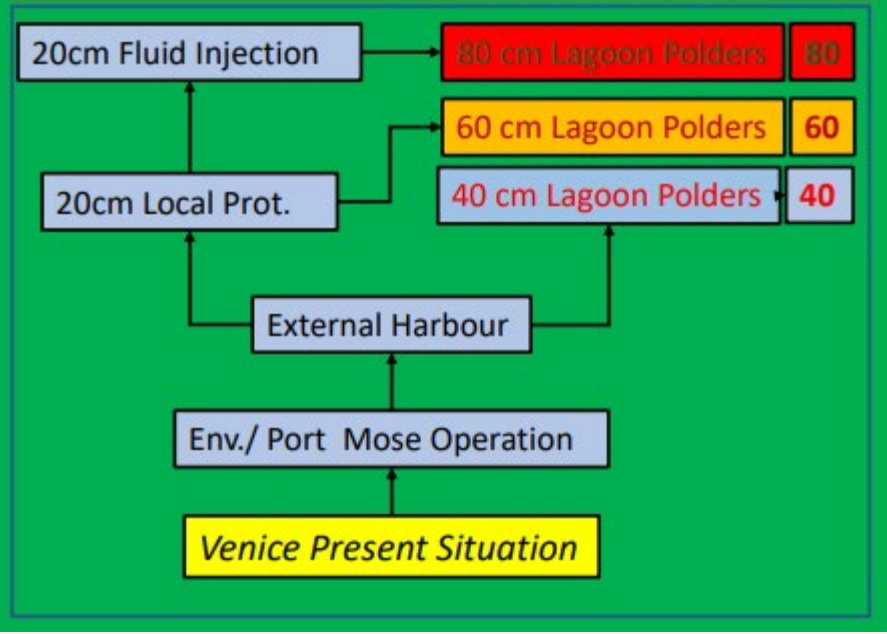
- **Venice protected** from floods in times of climate change and the **quality of the environment** has been improved.
- Great **flexibility** thanks to possibility to operate the system with partial closure of the barriers for environmental and social benefits
- **Multi-disciplinary knowledge** and experience in managing complex socio-ecological system (I-Storm founding member)
- Venice is an easy accessible ***living lab*** for other coastal cities facing climate and social changes

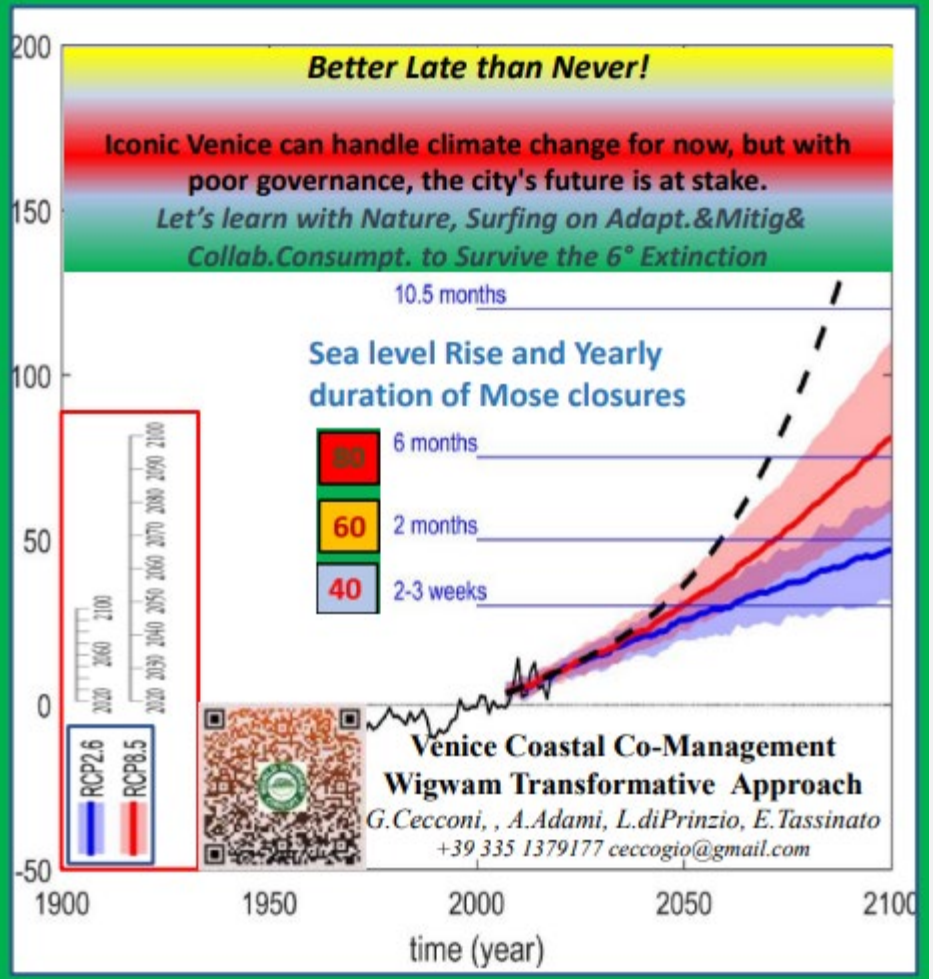
COPING WITH SEA LEVEL RISE : Closing only Lido in 65% flood case; Increase the loc. prot. of 10-20 cm



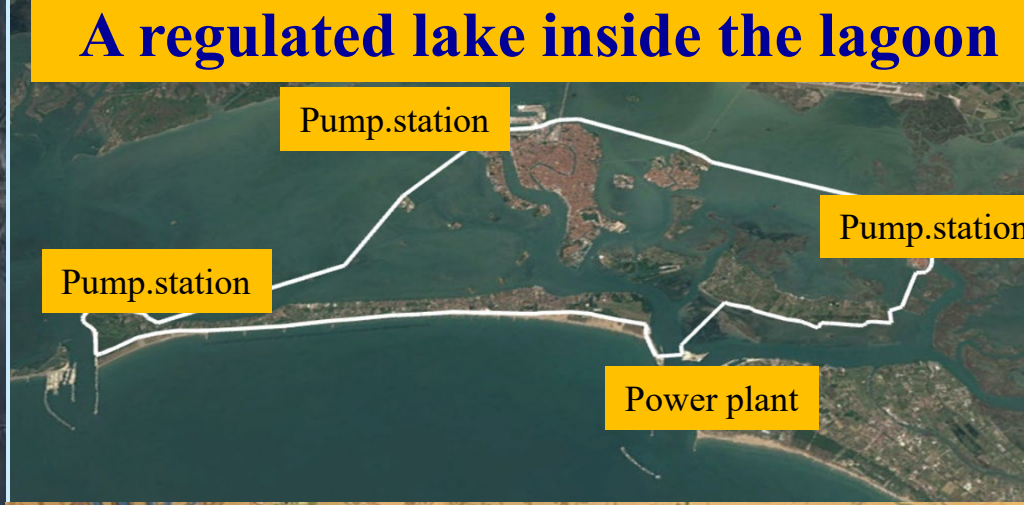
Le barriere mobili è probabile che, come conseguenza degli effetti congiunti dei dislivelli generati dal vento e dell'eustatismo debbano essere manovrate d'inverno quasi tutti i giorni


Mitigation
Nat.b.Sol.
Adaptation
Renewable energy
More efficient industrial processes
Eco-friendly transportation
Seasonal eating and less meat
Increase in urban green areas
Awareness-raising
Water and energy saving
More resilient agricultural species
Delimitation of coastal risk areas
Entomological surveillance
Flood barriers in urban spaces
Social Capability <--> Collaborative Consumptions


20cm Fluid Injection
80 cm Lagoon Polders
80
60 cm Lagoon Polders
60
20cm Local Prot.
40 cm Lagoon Polders
40
External Harbour
Env./ Port Mose Operation
Venice Present Situation


Better Late than Never!
Iconic Venice can handle climate change for now, but with poor governance, the city's future is at stake.
Let's learn with Nature, Surfing on Adapt.&Mitig& Collab.Consumpt. to Survive the 6° Extinction
10.5 months
Sea level Rise and Yearly duration of Mose closures
80
6 months
60
2 months
40
2-3 weeks
RCP2.6
RCP8.5
Venice Coastal Co-Management
Wigwam Transformative Approach
G.Cecconi, , A.Adami, L.diPrinzio, E.Tassinato
+39 335 1379177 ceccogio@gmail.com
200
150
100
50
0
-50
1900
1950
2000
2050
2100
time (year)

A regulated lake inside the lagoon



The Sandy Dike:

Bike and rails

Park trees

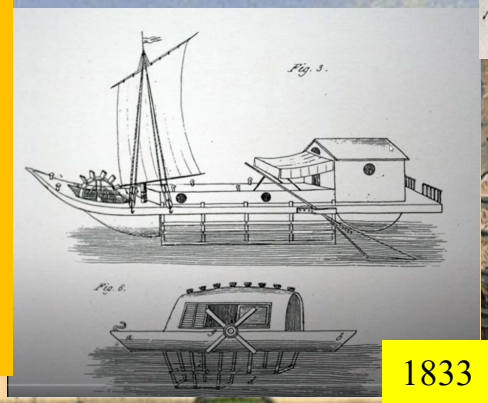
Local Food Garden

Sea Resort

Venice

Swimmable

Again



1833

1700

1950

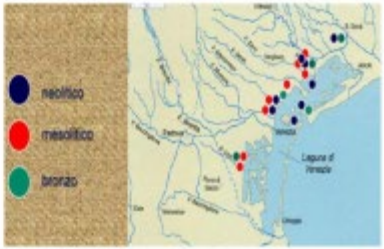
1833

Venice After Mose

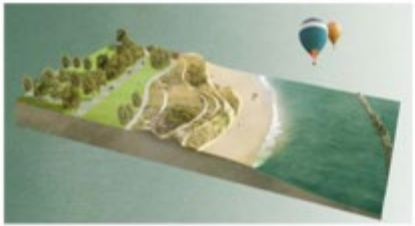
A Lagoon Water Farm

Co-evolution

Back to the future

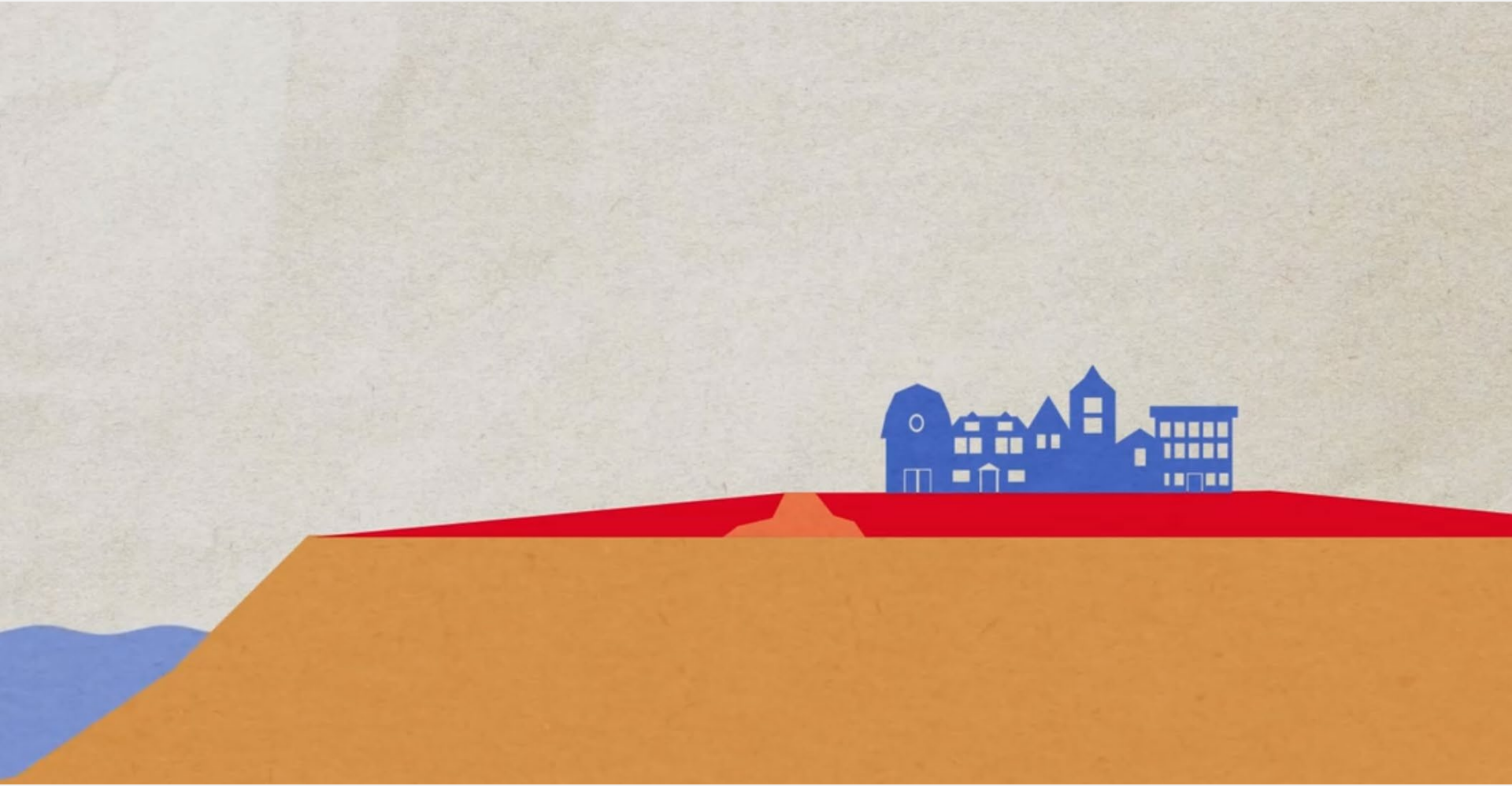


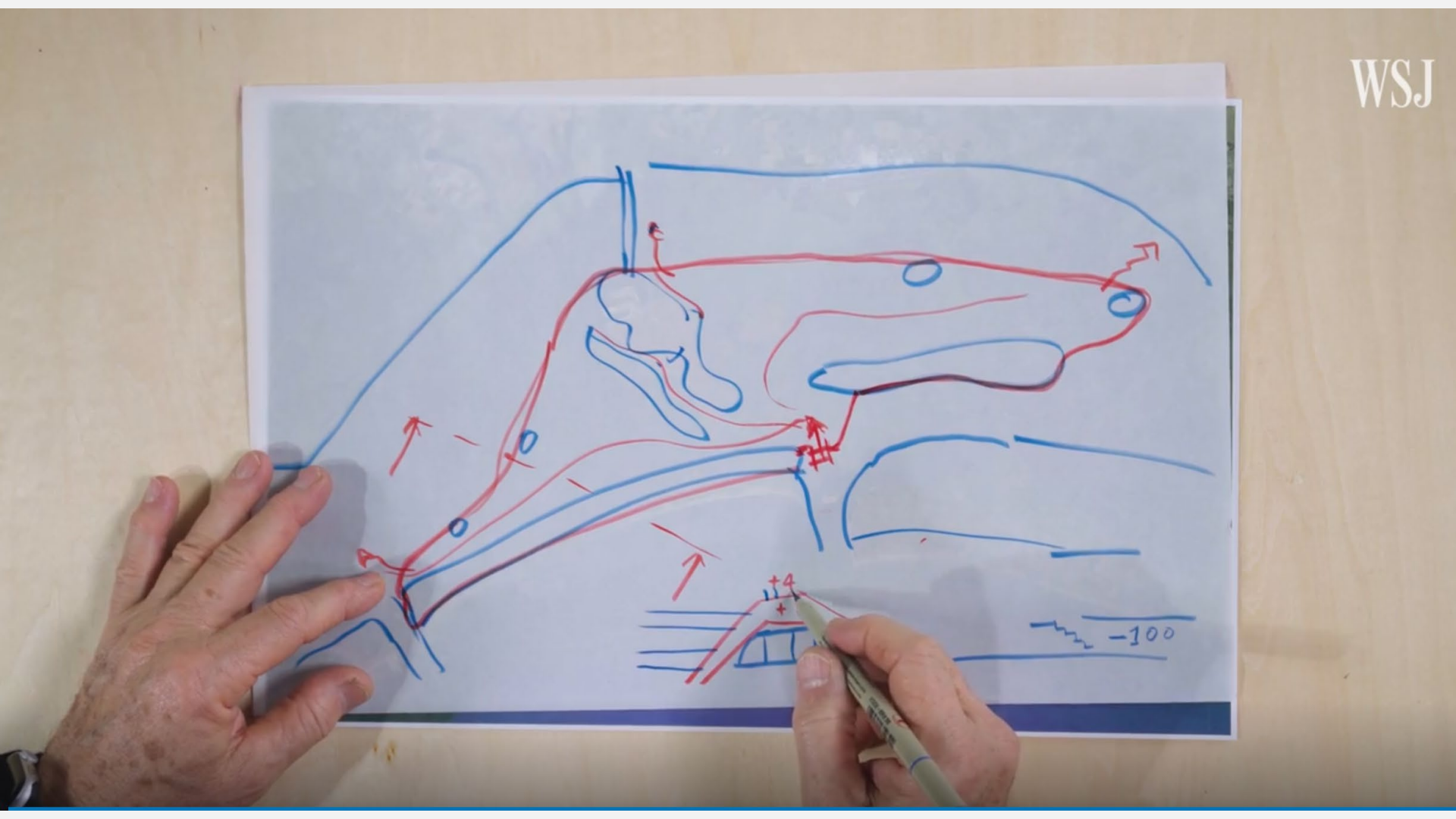
Regulated waters, horticulture, urban park, inner littoral, power production, renewable energies, safe fishing and marinas around the historical city



ATTILIO ADAMI
GIOVANNI CECCONI


WSJ




+4
-100

Venice Lab Adaptive Hospitality

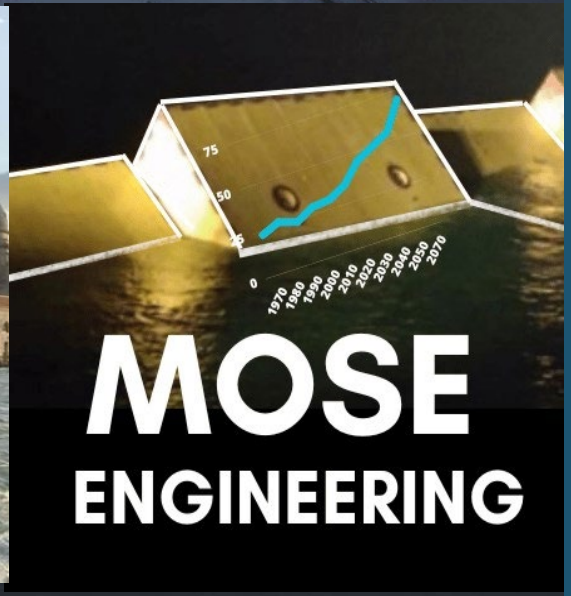
Venice continue to be the oldest city of the future
practicing formal and informal exchanges
with other water cities
for environmental restoration and disaster risk reduction.

This knowledge is also available both by institutional exchanges and by local community interactions (Bottom-Up) for adaptive hospitality

Thank you for your attention !

Ing. Giovanni Cecconi
Former dir. of the Mose Information Service
& Control Room of Consorzio Venezia Nuova
Ministry of Transport and Public Works
www.mosevenezia.eu

VENICE LAB



Founder of
Venice Lab Adaptive Hospitality for Global Communities
ceccogio@gmail.com www.venicelab.eu