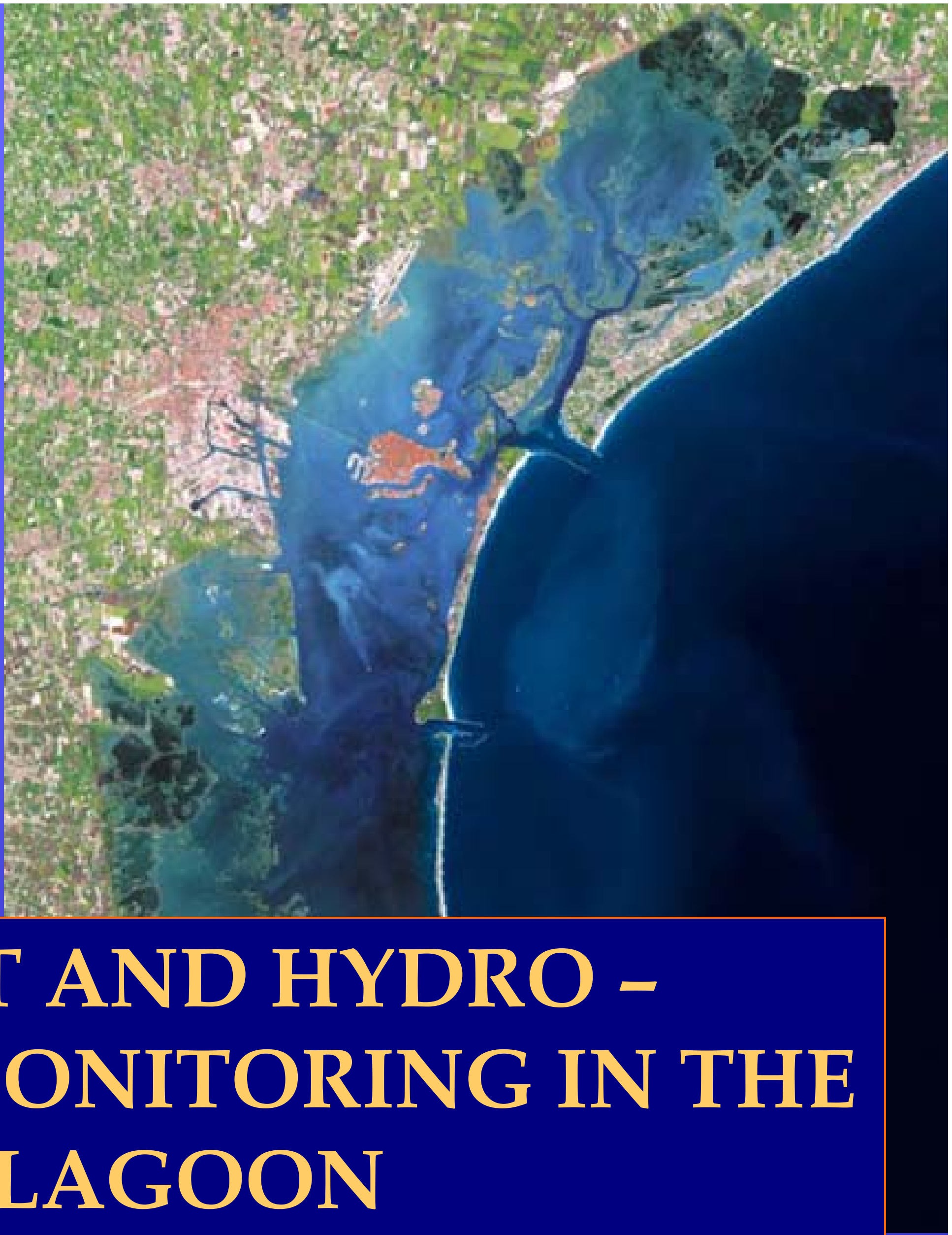
School on Wireless Networking for Scientific Applications in Developing Countries

TRIESTE

Third week

19-24 Feb 2007



MOSE PROJECT AND HYDRO – MORFOLOGICAL MONITORING IN THE VENICE LAGOON

Giovanni Cecconi

Consorzio Venezia Nuova

OUTLINE

A: Mose flood barriers: the importance of the project and a brief presentation of the project

B. Monitoring the impact of on-going construction works and the inlet on the hydraulic properties:

1. bathymetric evolution of the sandy bottom at the inlets
2. energy loss through the inlets
3. monitoring velocities and tidal flow
4. residual flow and index of river contamination

The lagoon of Venice: an instable and complex ecosystem

The lagoon of Venice: an instable and complex ecosystem

Fish farms – Valle Zappa

Salt marshes, channels and tidal creeks

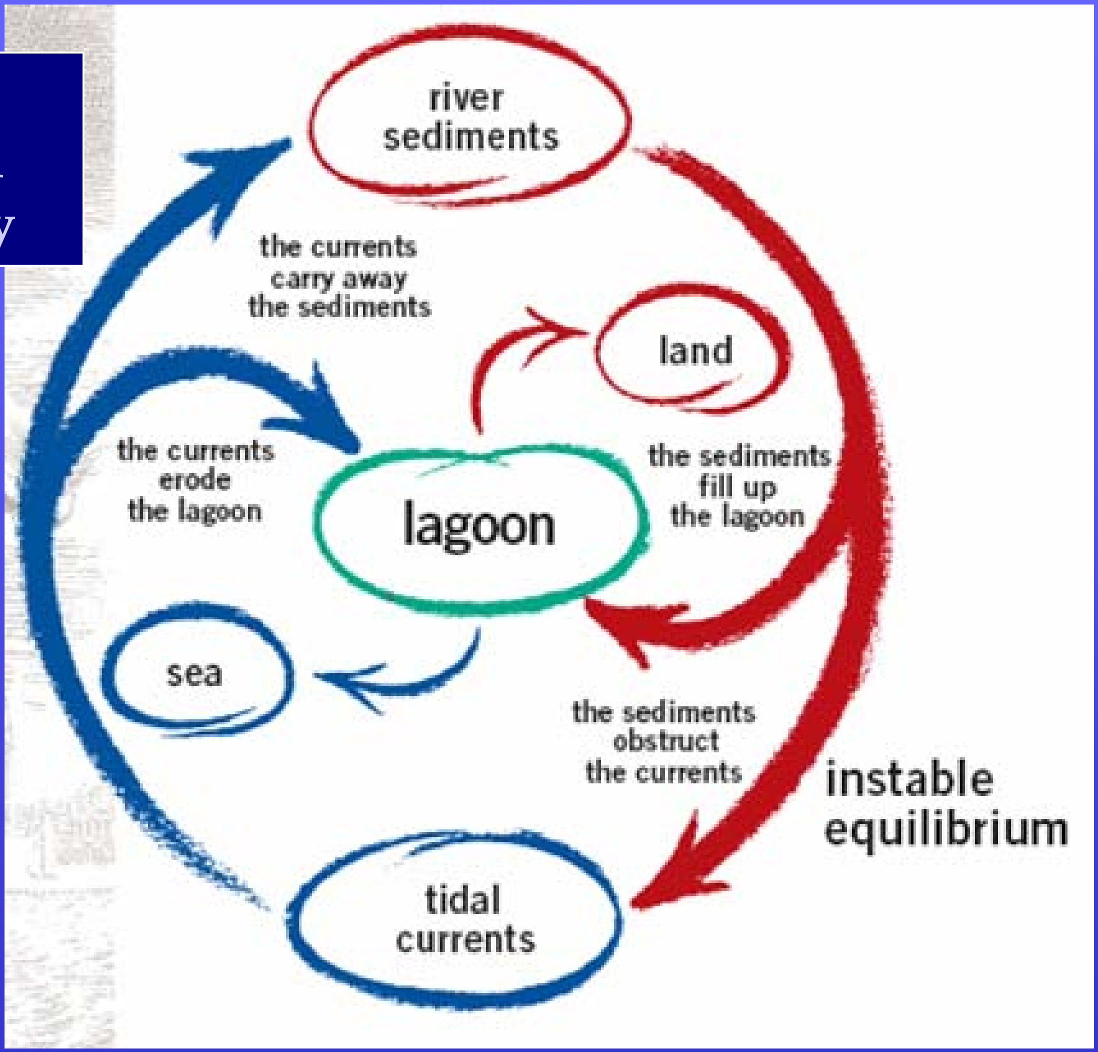
The lagoon of Venice: an instable and complex ecosystem

islands –
Island of Torcello

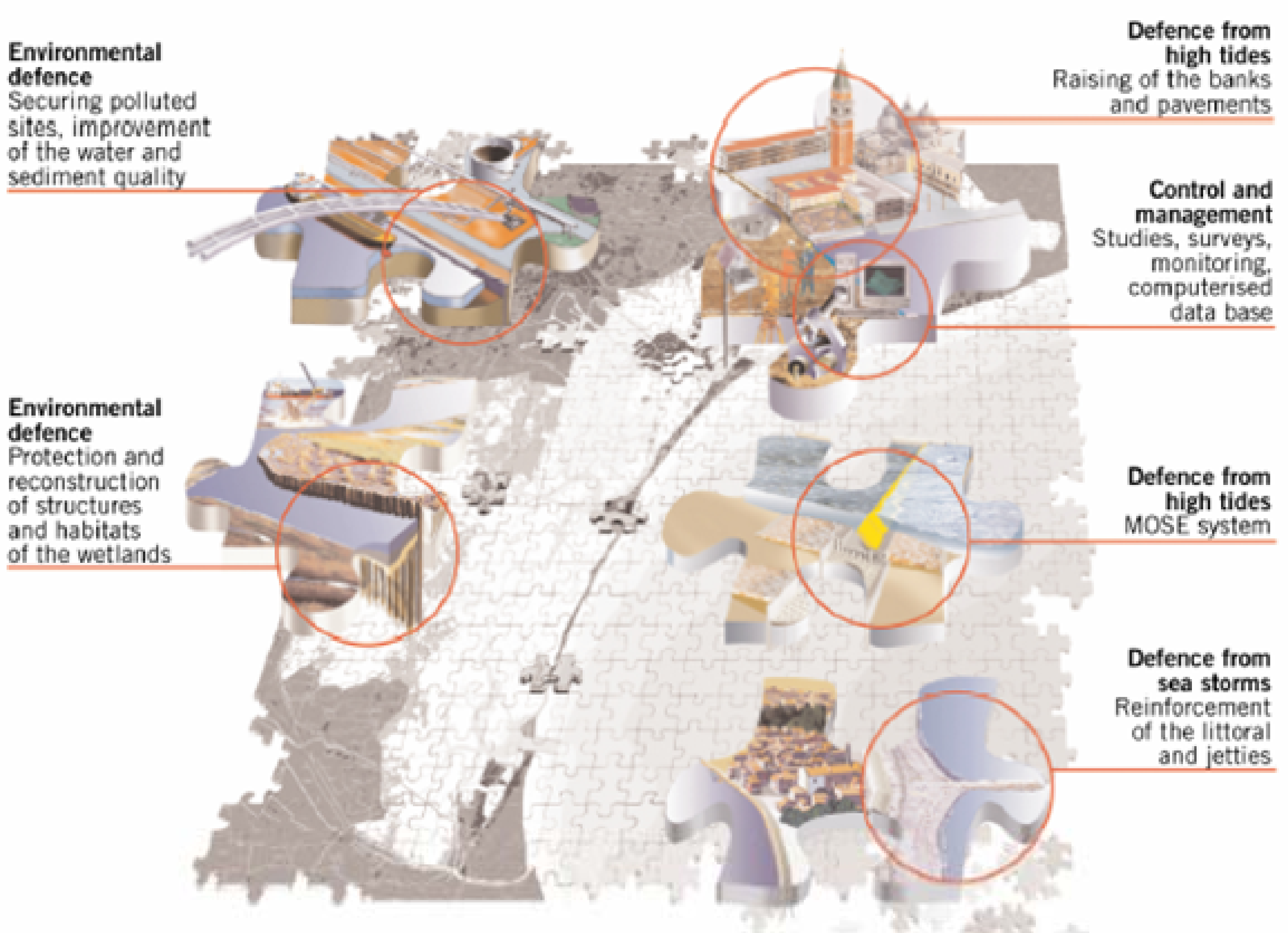
Littorals –
Pellestrina littoral

The lagoon of Venice: an instable and complex ecosystem

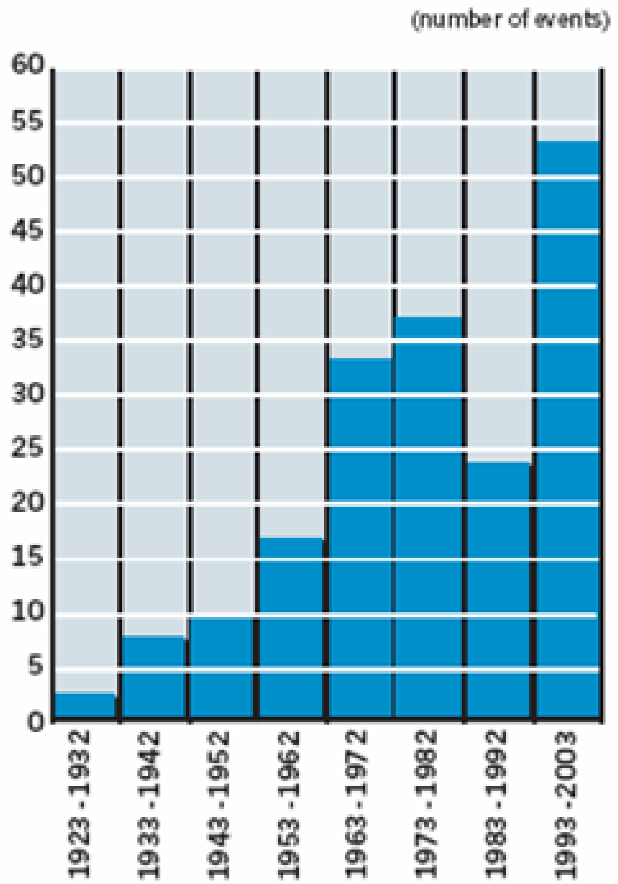
Is a transitional environment in a state of instability



SYSTEMS OF INTERVENTIONS



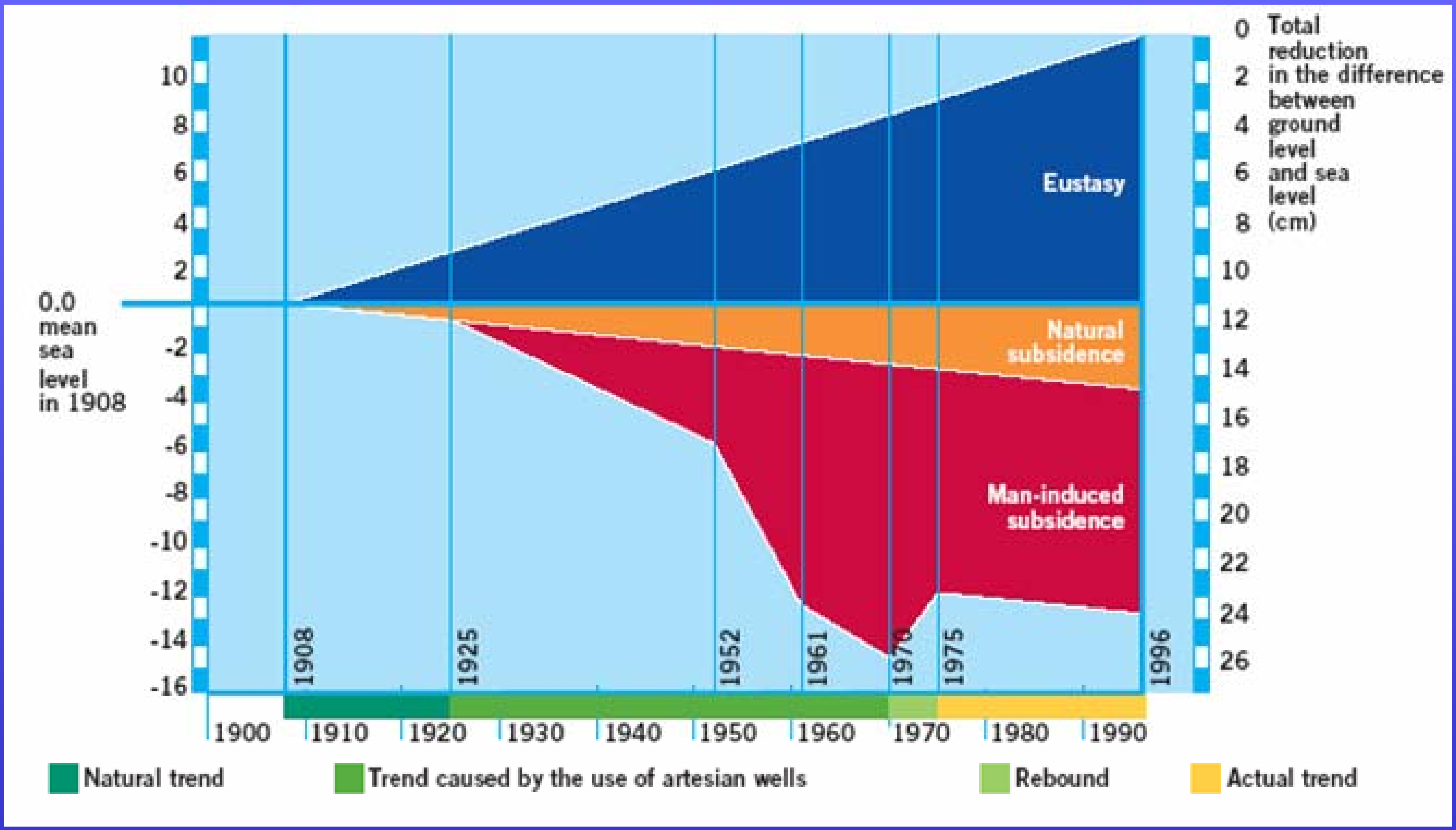
Frequency of high tides >= 110 cm



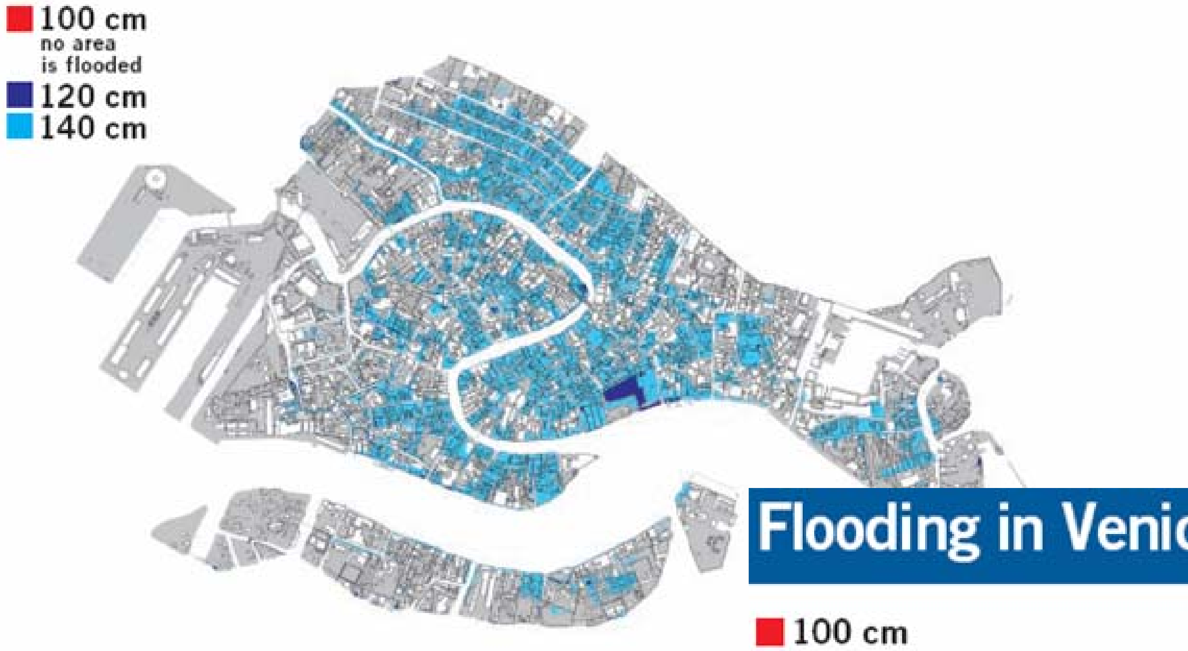
	(tidal levels in cm)
November 16, 2002	147
November 6, 2000	144
Dicember 8, 1992	142
February 1, 1986	159
December 22, 1979	166
February 14, 1979	140
November 3, 1968	144
November 4, 1966	194
October 15, 1960	145
November 12, 1951	151

Between 2003 and 2005, there were six cases of tides ≥110 cm

Relative see level rise



Flooding in Venice at the turn of the 20th century

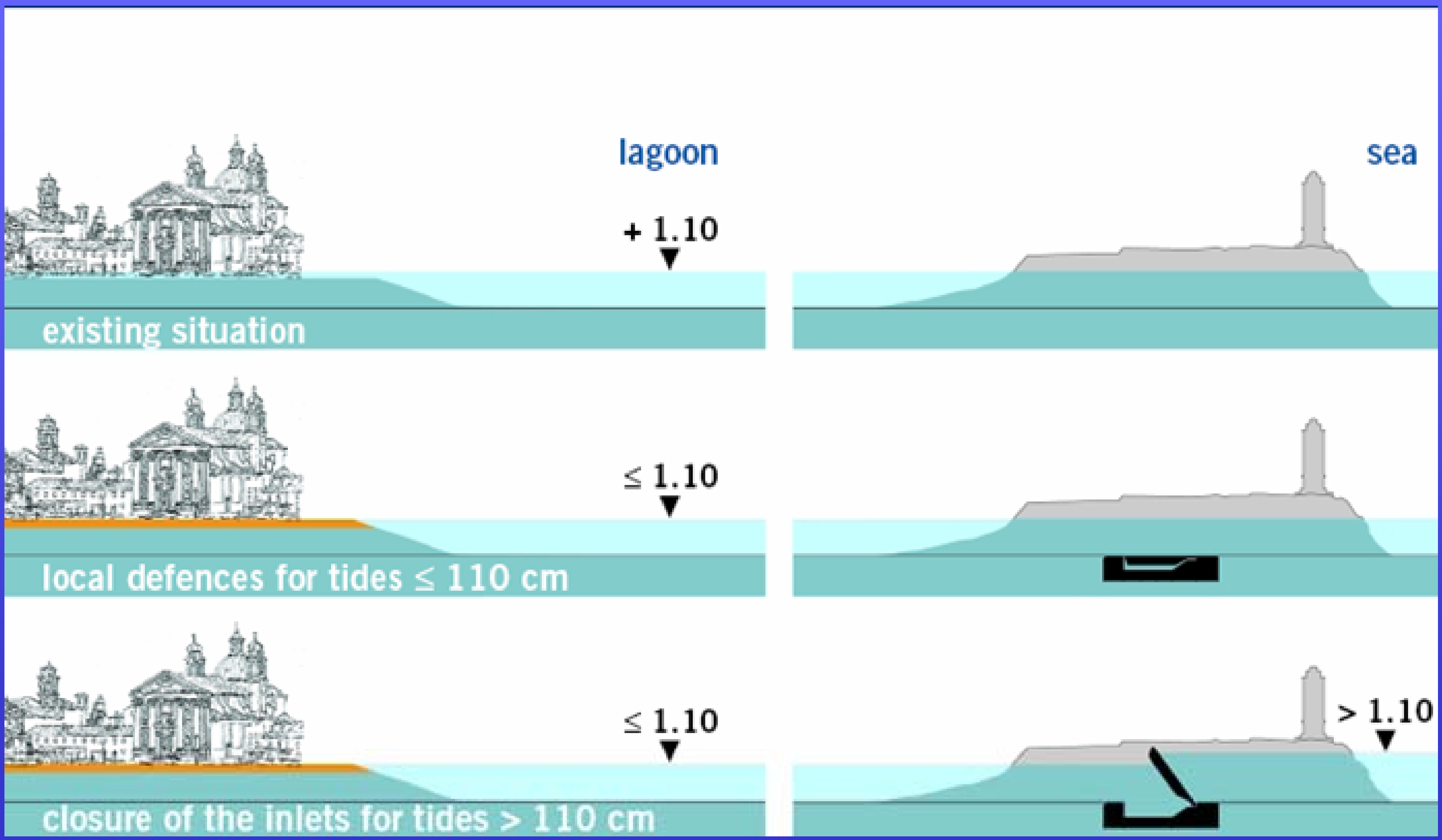


Flooding in Venice today

High water. Chioggia

High water. Island of Murano

SYSTEMS OF INTERVENTIONS



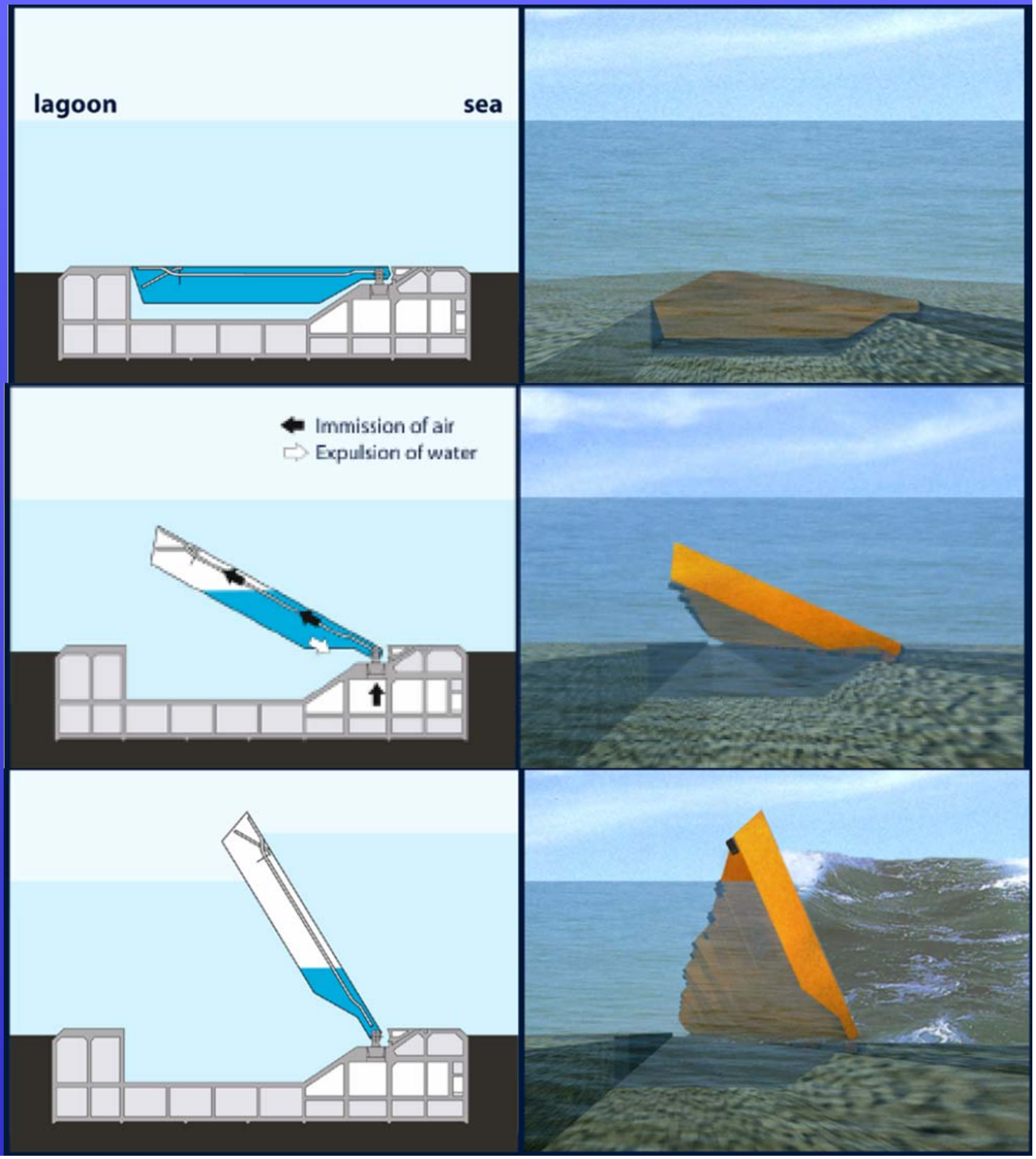
MOBILE BARRIERS AT THE LAGOON INLETS

MOBILE BARRIERS AT THE LAGOON INLETS

HOW THE FLOOD GATES WORK

DEFENCE AGAINST EXCEPTIONALLY HIGH TIDES:

closures of the inlets for tides > 110 cm



25% of the Mose flood barrier is under construction

33% financed

THE PROJECT - LIDO INLET

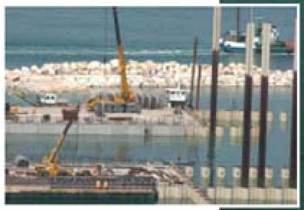
SITUATION AT JUNE 2006

LIDO INLET WORK SITES

THE PROJECT - MALAMOCCO INLET

SITUATION AT JUNE 2006

MALAMOCCO INLET
WORK SITES



navigation lock

the breakwater

THE PROJECT - CHIOGGIA INLET

SITUATION AT JUNE 2006

The new lay-out
of the inlet after
the realization
of the MOSE System
for the defence from
high tides

1. Refuge haven
2. Northern jetty (existing)
3. Row of gates
4. Southern jetty (existing)
5. Breakwater

CHIOGGIA INLET WORK SITES

IMPACT OF FIXED STRUCTURES ON TIDAL FLOW

-5 cm average storm surge reduction

<10% permanent tidal flow reduction

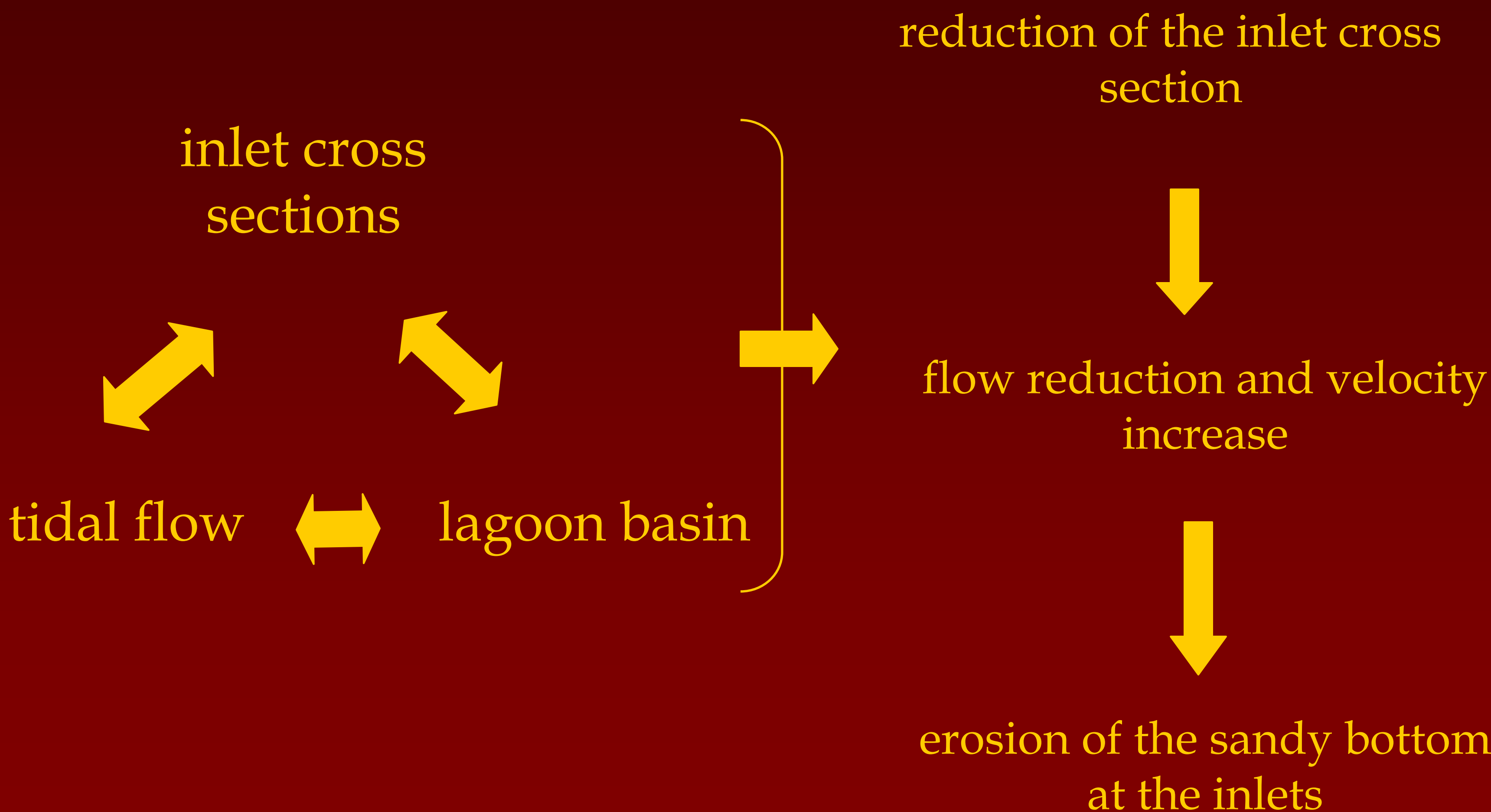
We are monitoring the impact on-going construction works measuring:

1. bathymetric evolution of the sandy bottom at the inlets
2. energy loss through the inlets
3. velocities and tidal flow
4. residual flow and index of river contamination

We are building up a DATABASE of monitored data for calibration and validation of hydro-morphological models

(hybrid models continuously tuned with experimental data)

Inlets evolution

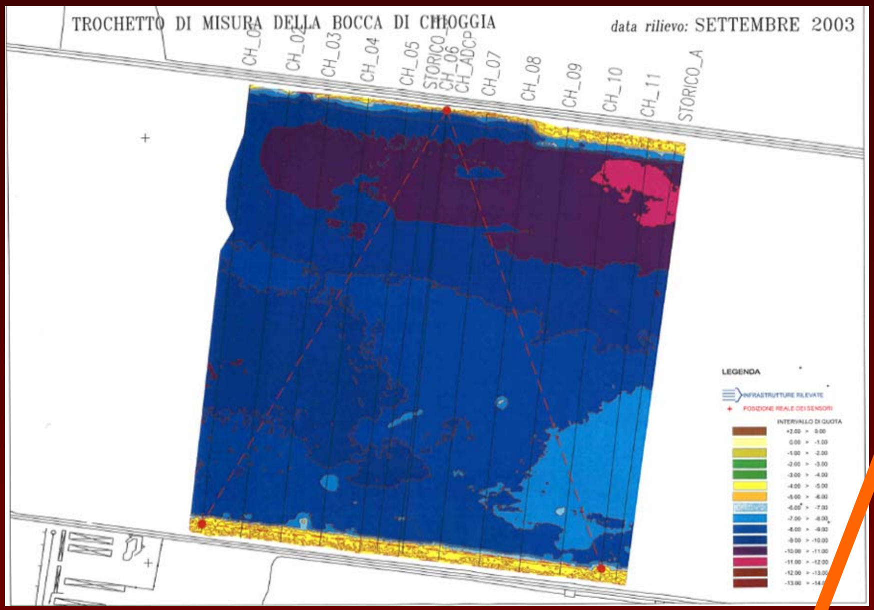


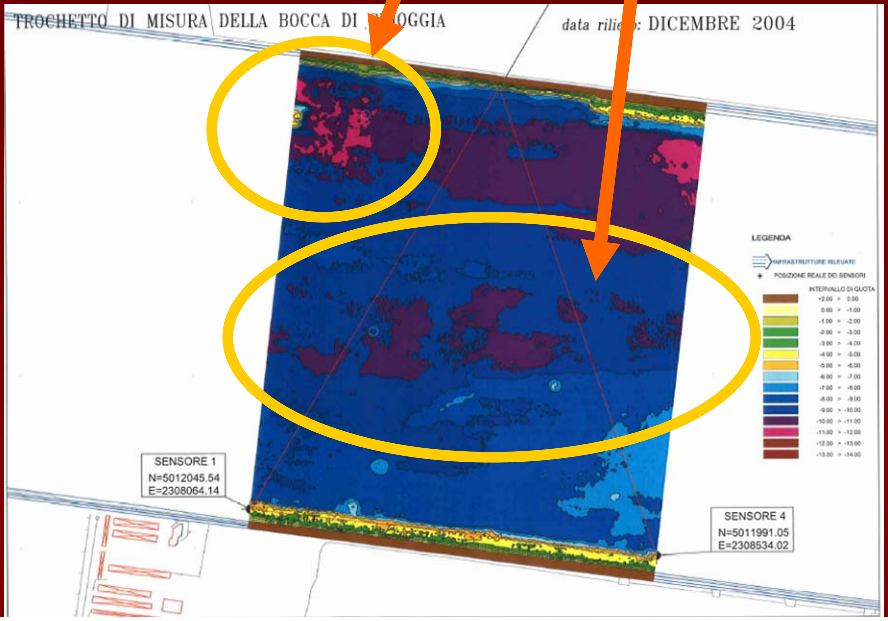
BATHYMETRIC EVOLUTION OF THE SANDY BOTTOM AT THE INLETS

acoustic multibeam survey for monitoring bathymetric changes

⬇

Erosions or fills can be part of the construction works (dredge of a new navigation channel, building of a new reef…) or the result of velocity changes due to the on-going construction works





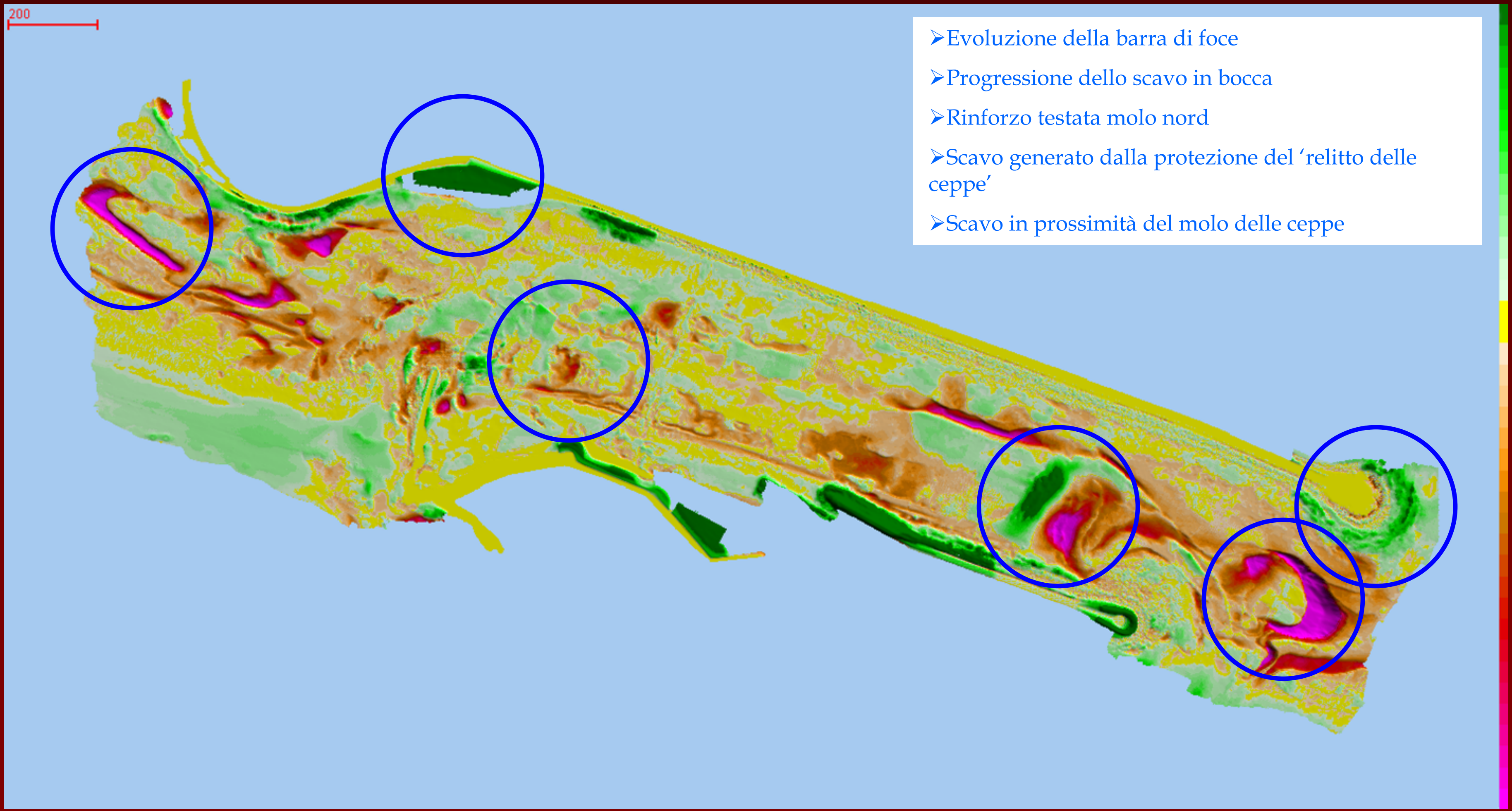
<u>Chioggia inlet:</u>

1.building of a break-water

2.dredge of the navigation channel

BATHYMETRIC EVOLUTION OF THE SANDY BOTTOM AT THE INLETS

evolution of Malamocco inlet from 1999 to October 2006



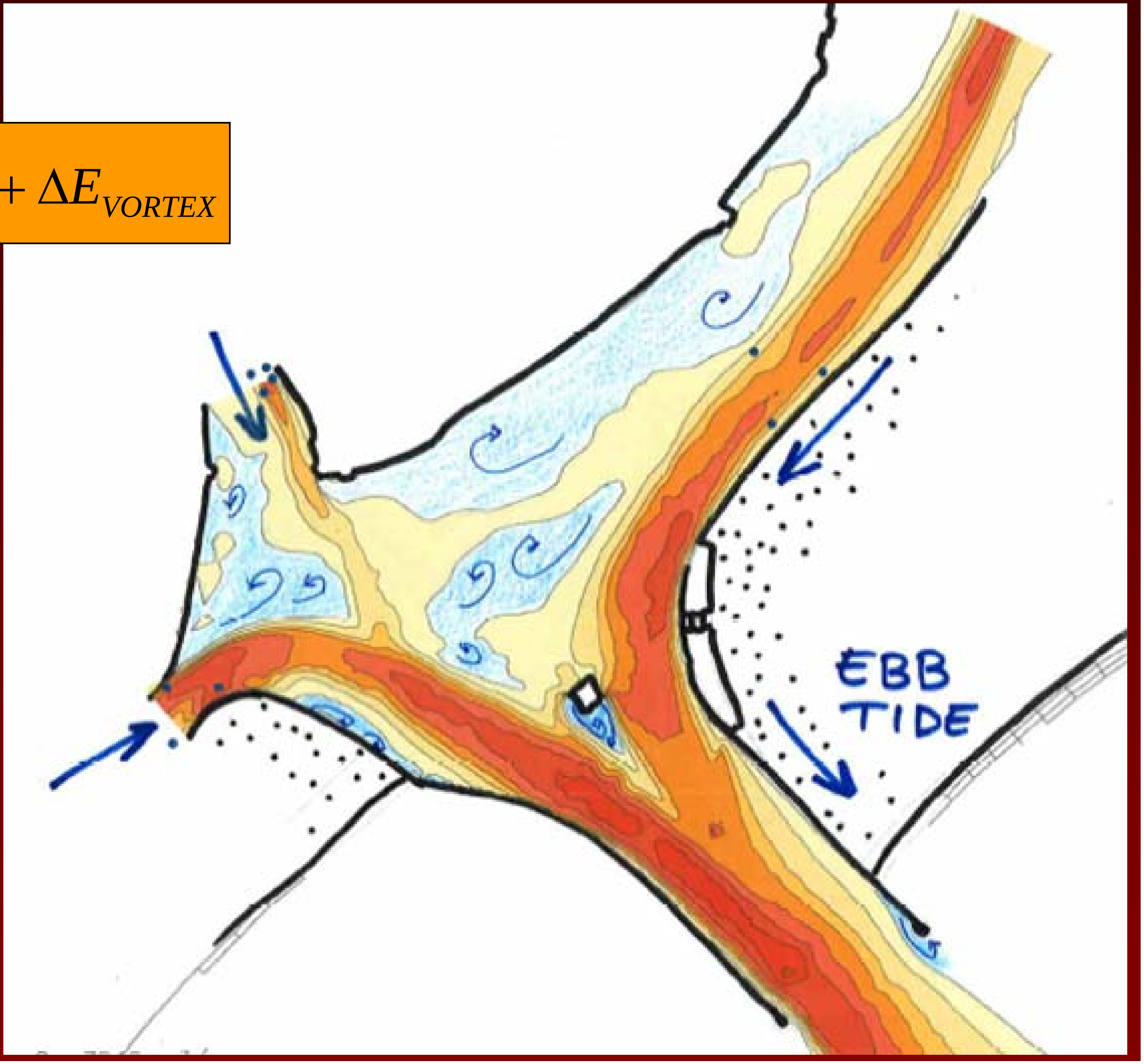
ENERGY LOSS THROUGH THE INLETS

$$\Delta E_{TOT} = \Delta E_{FRICTION} + \Delta E_{VORTEX}$$

1. Every inlet has different friction coefficient (depending on bottom surface, length of the reefs..)
2. Every inlet has different volumes of vortex and different volumes of moving flow
3. The situation is different at flood and ebb flow

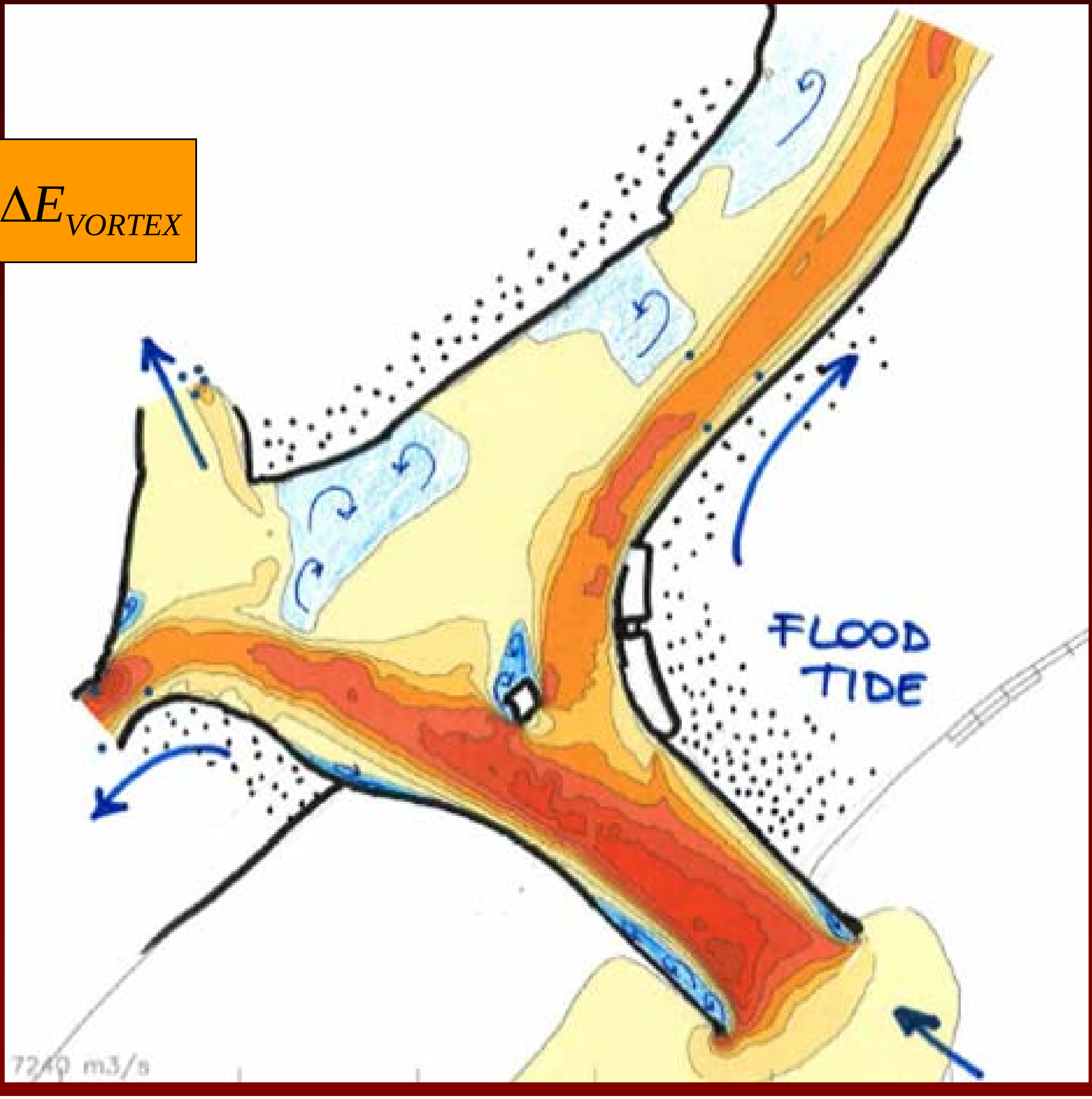
ENERGY LOSS THROUGH THE INLETS

$$\Delta E_{TOT} = \Delta E_{FRICTION} + \Delta E_{VORTEX}$$



ENERGY LOSS THROUGH THE INLETS

$$\Delta E_{TOT} = \Delta E_{FRICTION} + \Delta E_{VORTEX}$$

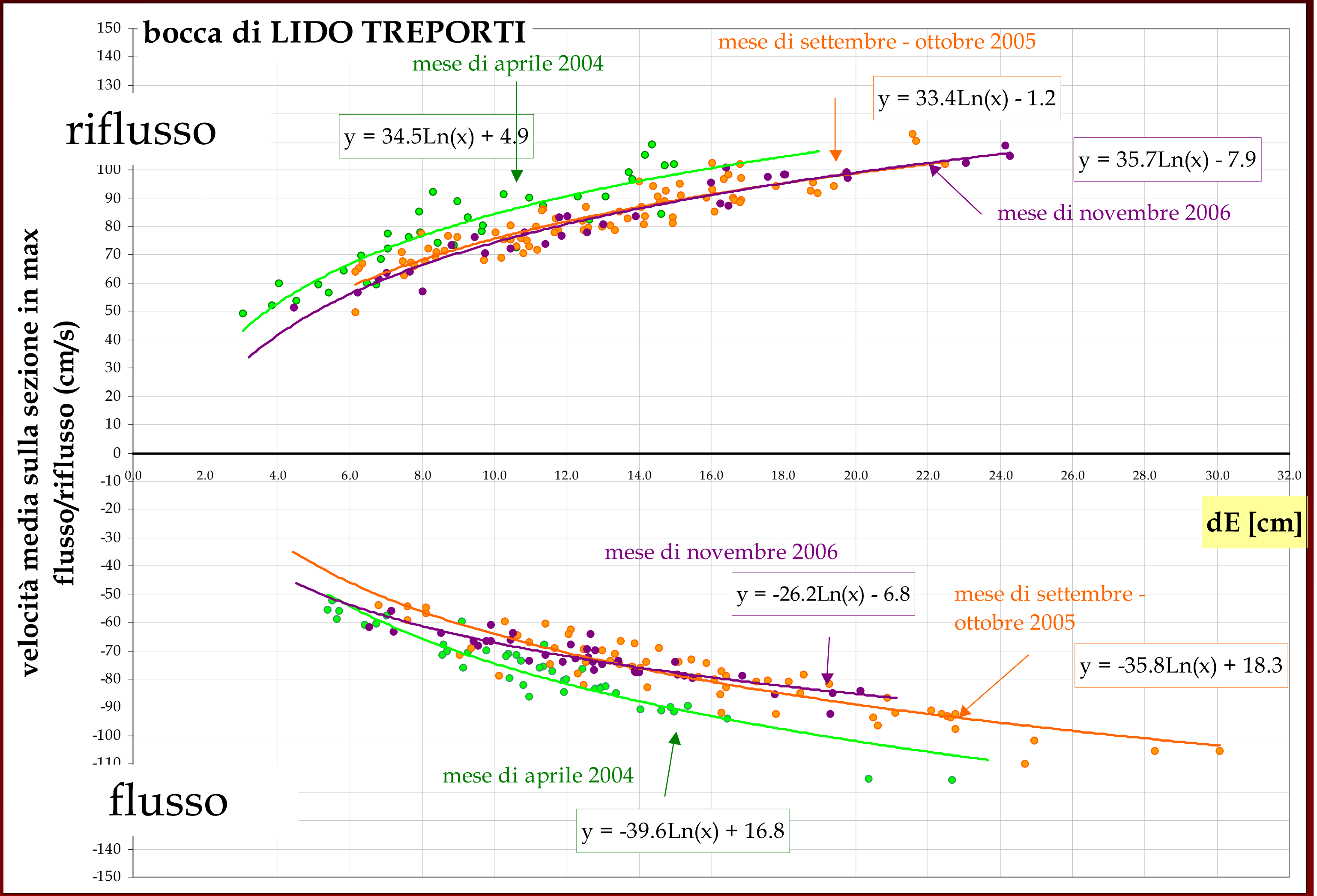


ENERGY LOSS THROUGH THE INLETS

CURVE DI CONTROLLO

intensity of tidal flow

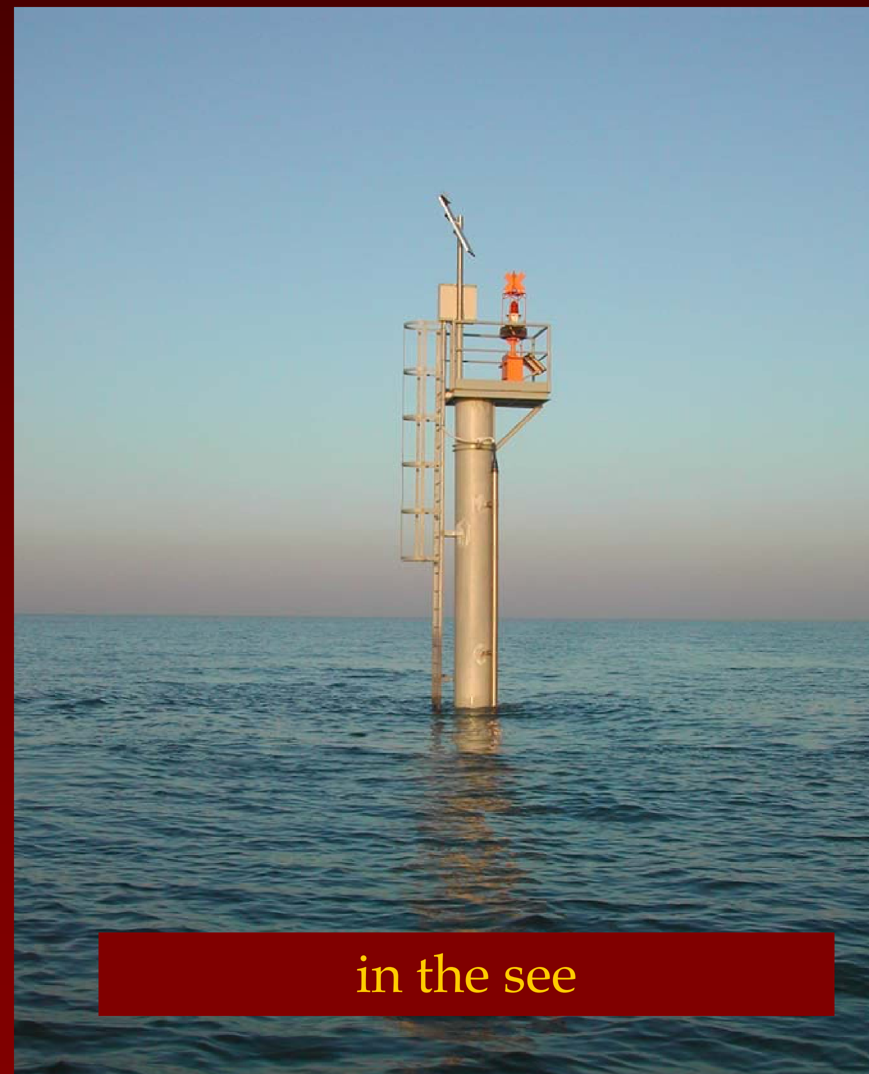
energy loss



MONITORING VELOCITIES AND TIDAL FLOW

TIDAL GAGES


in the lagoon


in the see

MONITORING VELOCITIES AND TIDAL FLOW

INSTALLATION OF THE ACOUSTIC FLOW METERS

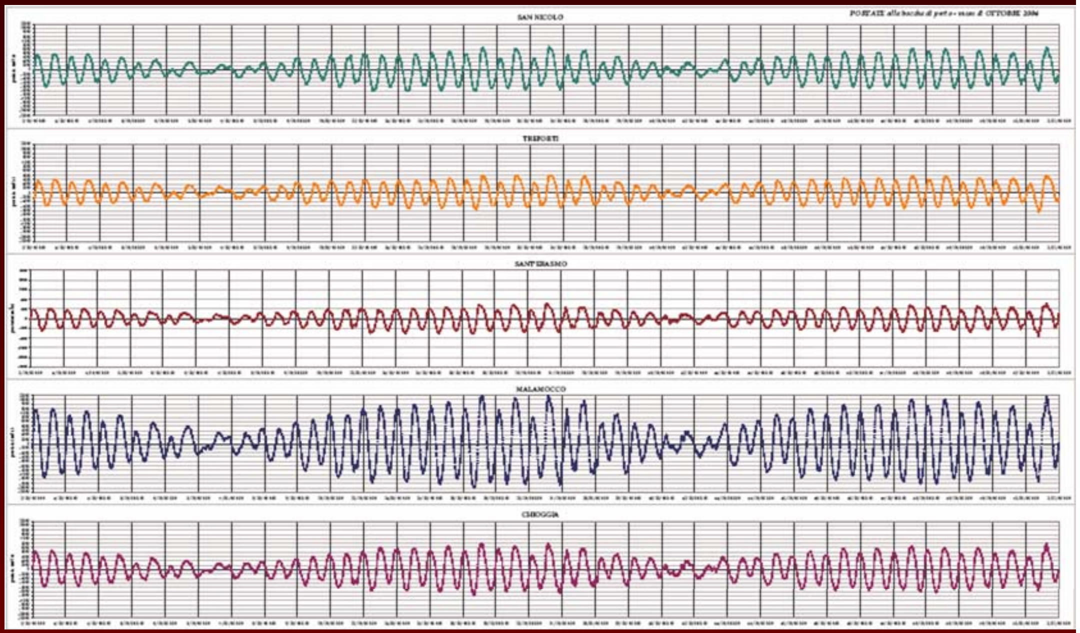
MONITORING VELOCITIES AND TIDAL FLOW

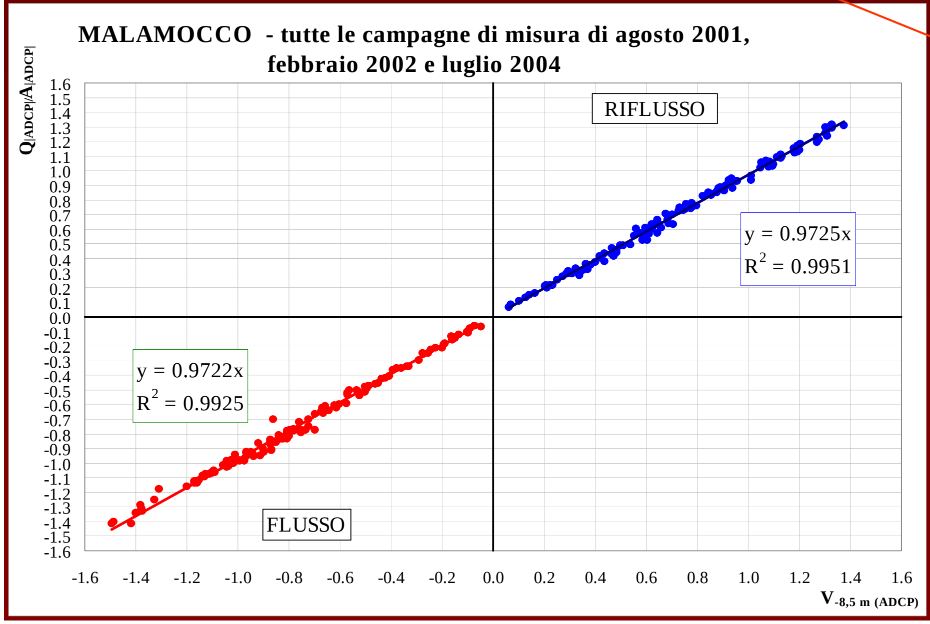
Calibration of the acoustic flow meters:

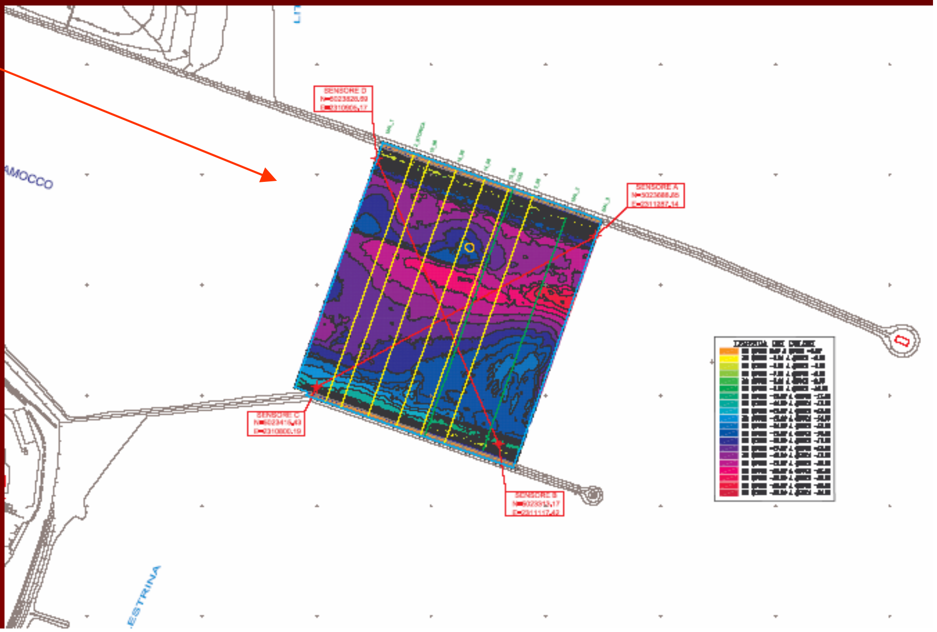
-Bathimetric survey

-ADCP shape velocity factor

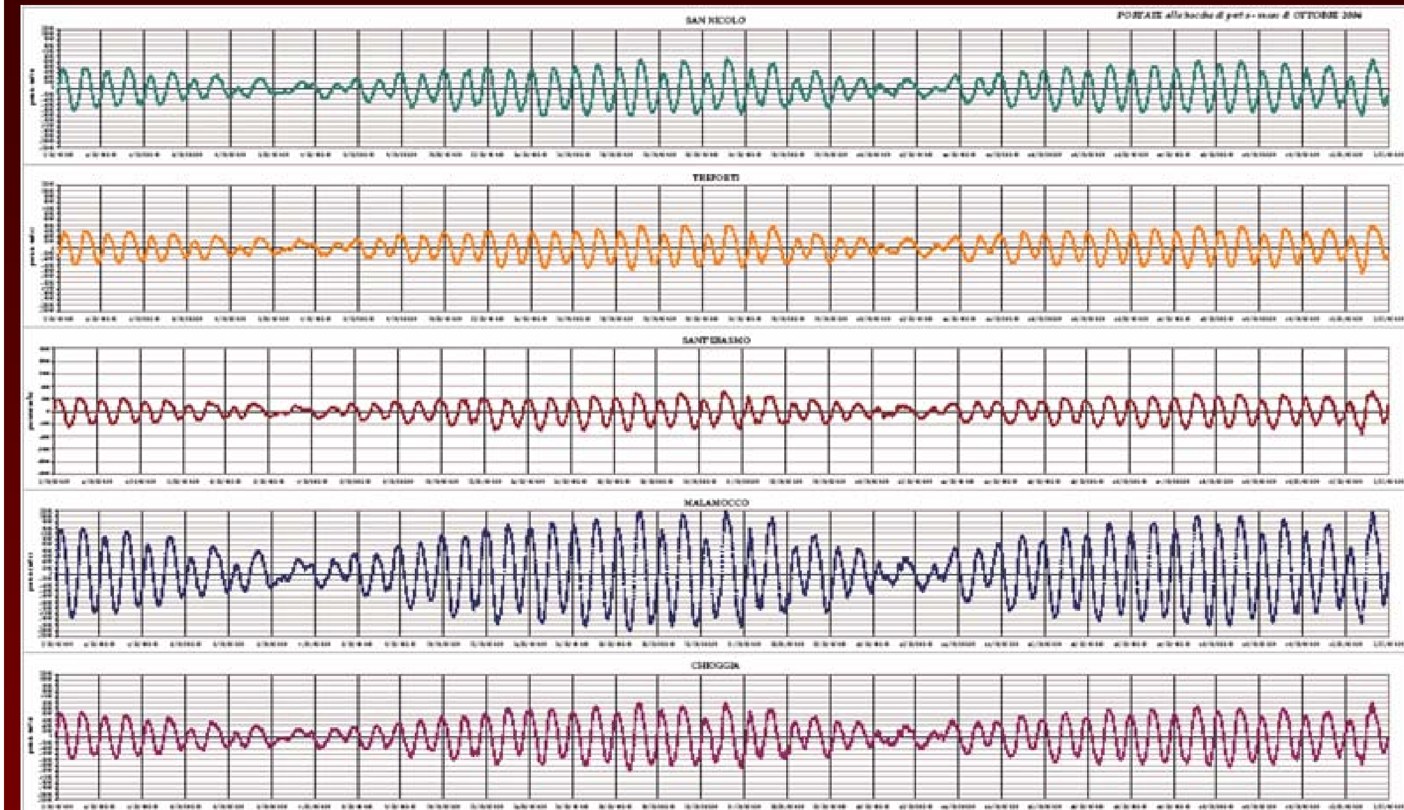
$$Q = k\,A\,v_{-8.5}$$







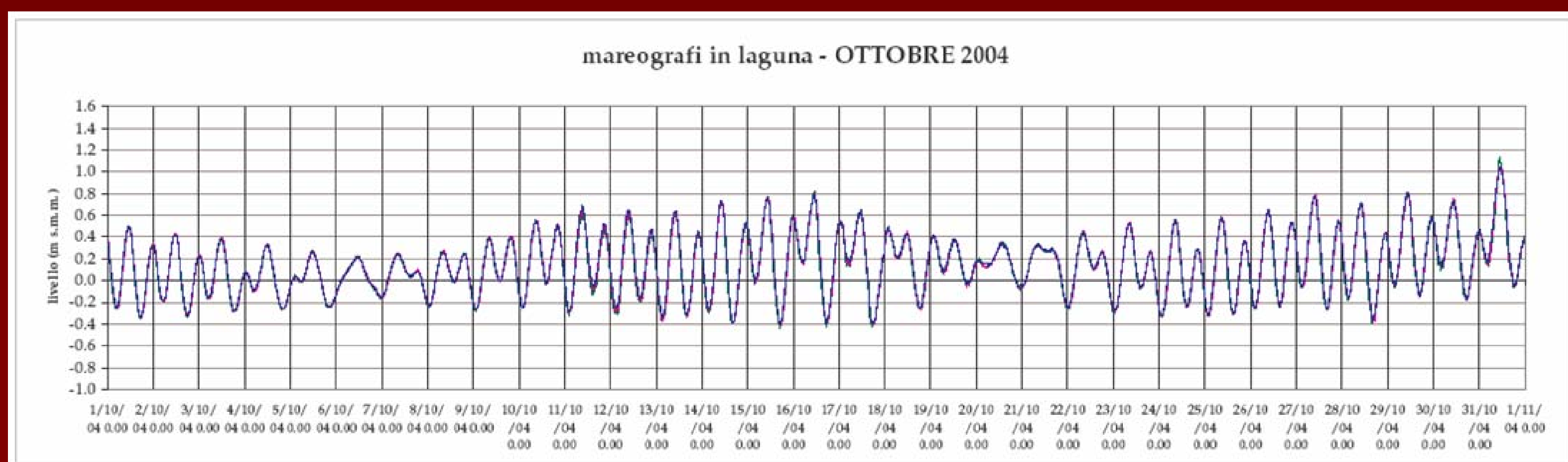
MONITORING VELOCITIES AND TIDAL FLOW



misure di

VELOCITA' DI CORRENTE

LIVELLI



MONITORING VELOCITIES AND TIDAL FLOW

BOCCA DI LIDO

MONITORING VELOCITIES AND TIDAL FLOW

BOCCA DI MALAMOCCO

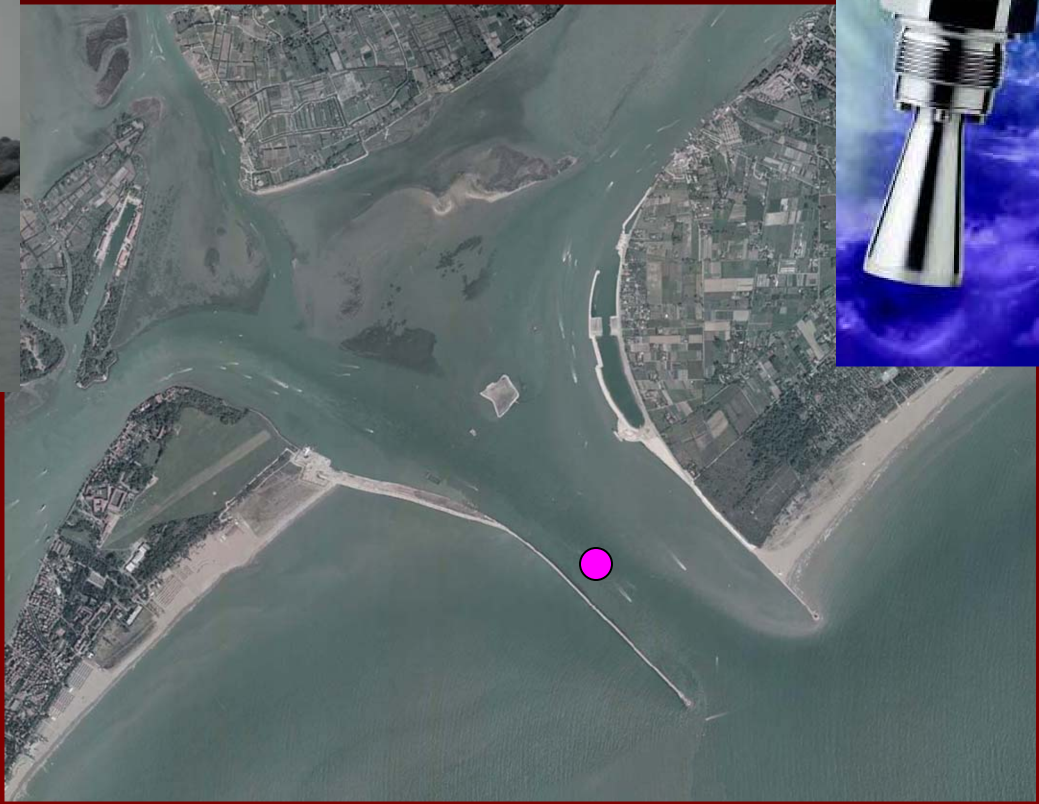
MONITORING VELOCITIES AND TIDAL FLOW

BOCCA DI CHIOGGIA

MONITORING VELOCITIES AND TIDAL FLOW

BOCCA DI LIDO :

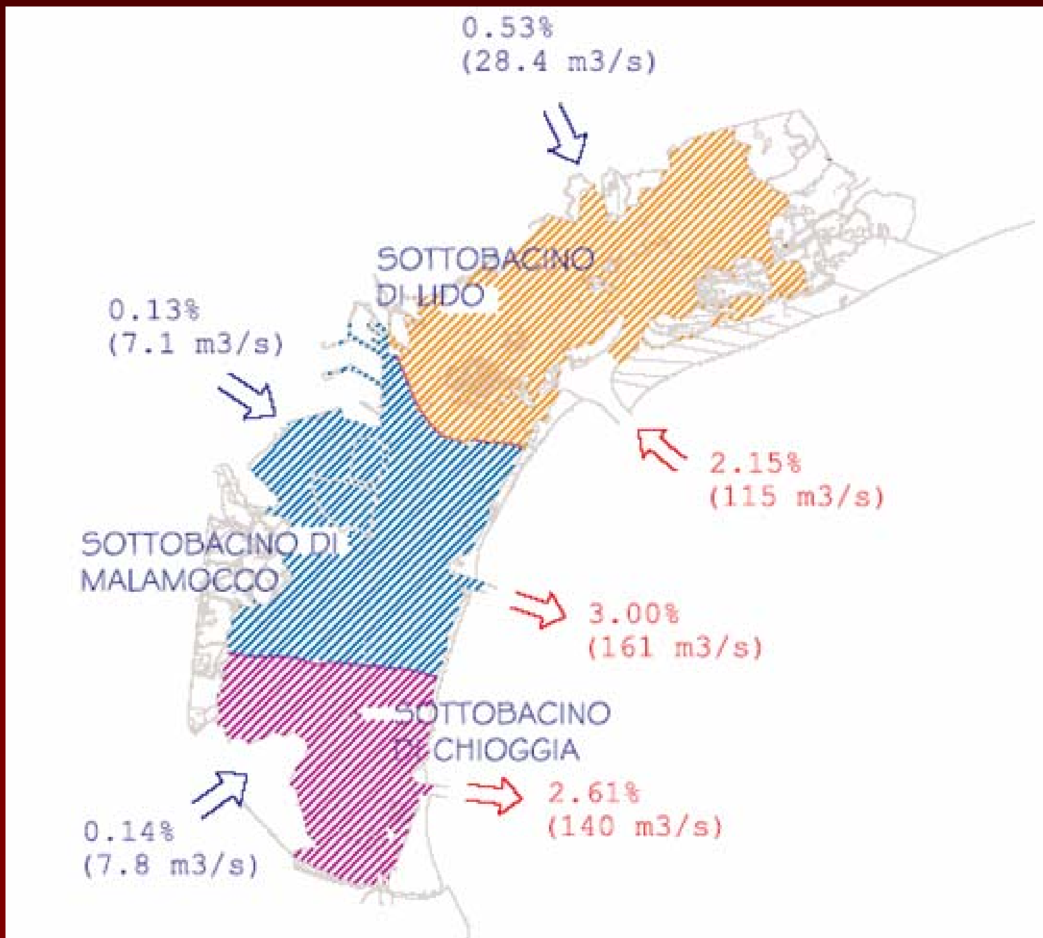
experimental installation of a radar tidal gage and waverecorder



RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION

Evidence of ground-water richarge into the lagoon

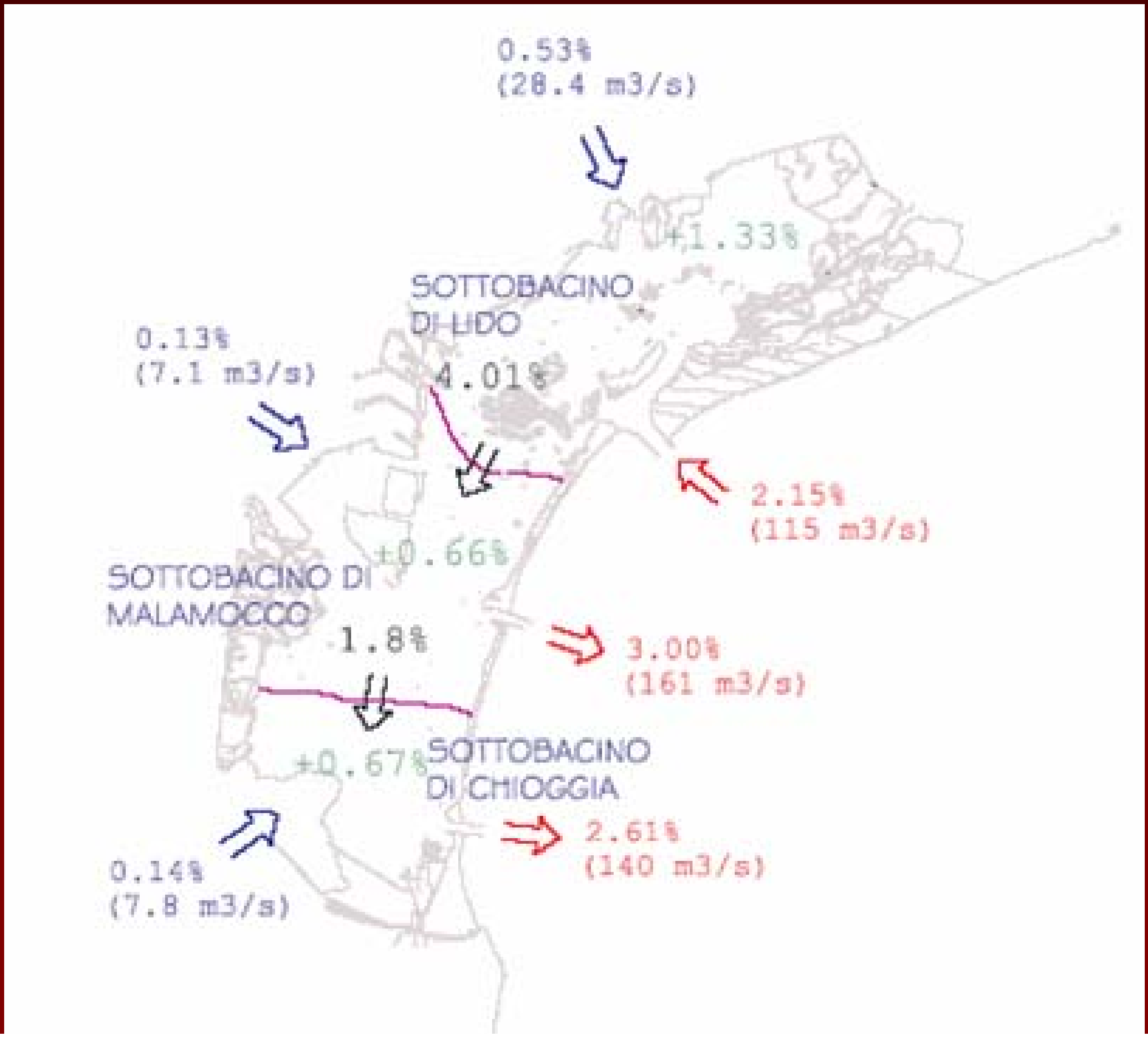
RESIDUAL FLOW as a percentage of the tidal flux (5 333 m3/s)



2.96% -
<u>5.60%=</u>
2.65%
140 m3/s

RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION

First estimation of the grownd-water richarge into the lagoon



RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION

installation of salinity probes MICROCAT CTD at the inlets at different depth

SBE 37-SI MicroCAT CT Monitor

RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION

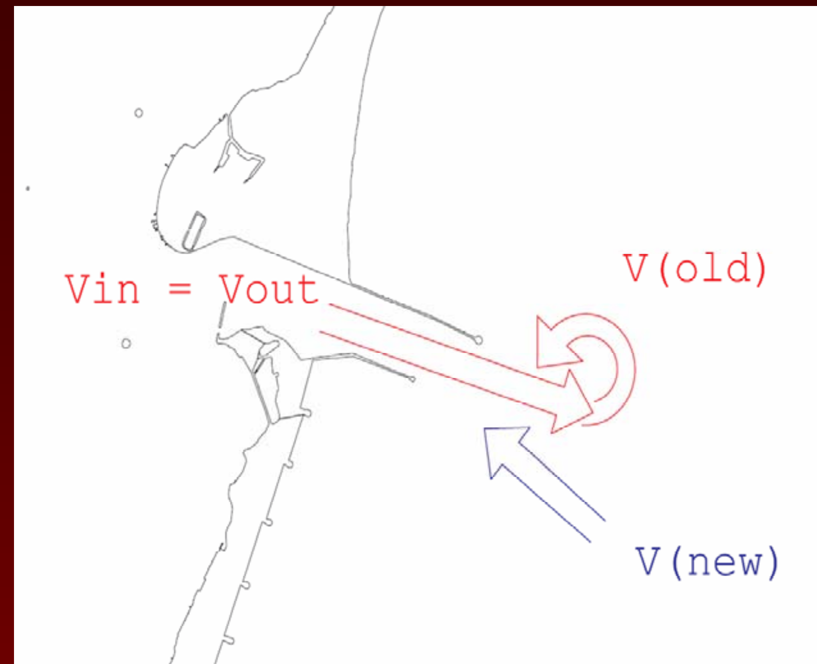
Tidal flushing at the lagoon inlets:
water recirculation at sea

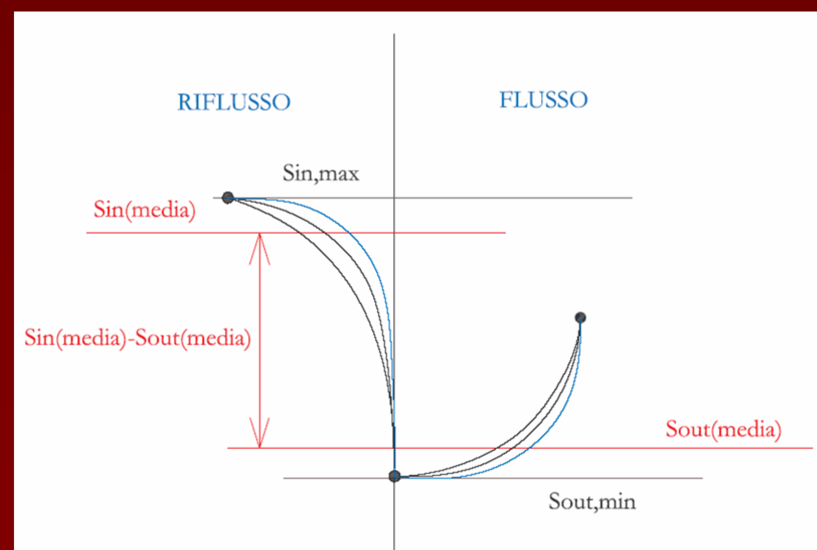
$$\text{Renewal} = \frac{V(new)}{Vin}$$

$$\text{Renewal} = \frac{S_{in,mean} - S_{out,mean}}{S_{in,max} - S_{out,mean}}$$

$$Vin = V(old) + V(new)$$

$$\text{Recirculation} = \frac{V(old)}{Vin} = 1 - \text{Renewal}$$



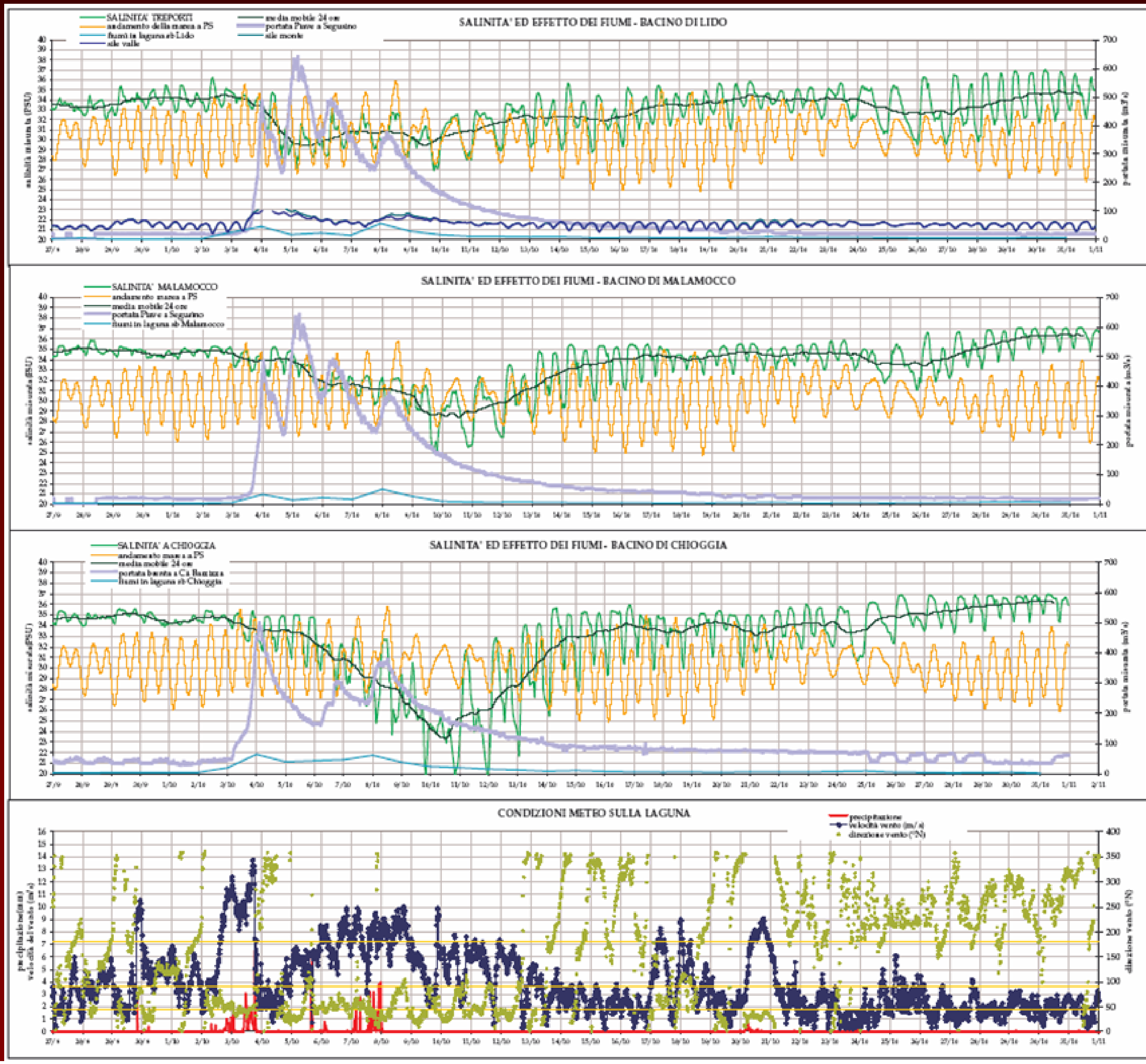


RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION

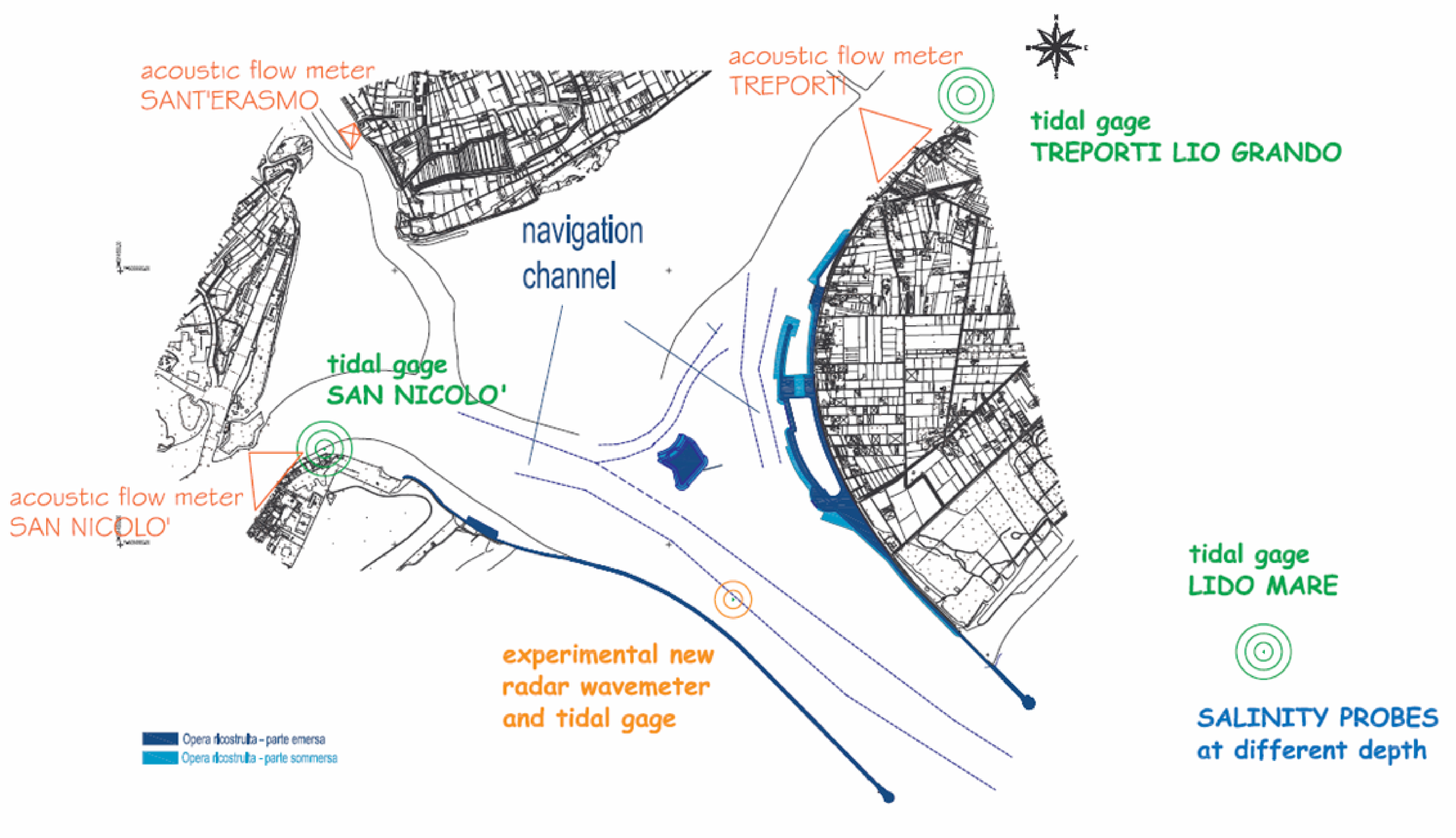
Tidal flushing at the lagoon inlets: water recirculation at sea

data campagna di misura	bocca di porto	Salinità max in ingresso	Salinità minima in riflusso	Volume scambiato (m3)	Carico di sale in ingresso (t)	Carico di sale in uscita (t)	Ricambio	Ricircolo	Efficienza del ricambio rispetto al ricambio ideale in assenza di ricircoli
30-31/10/02	**lido**	34.68	31.83	128 812 000	4 368 000	4 282 000	**0.46**	**0.54**	**0.23**
06-07/11/02	**lido**	34.50	31.93	188 424 000	6 387 000	6 140 000	**0.68**	**0.32**	**0.51**
12-13/11/02	**malamocco**	35.89	34.34	83 926 000	3 007 000	2 931 000	**0.94**	**0.06**	**0.58**
01-02/04/03	**malamocco**	35.14	34.37	214 305 000	7 489 000	7 378 000	**0.73**	**0.27**	**0.67**
22-23/03/03	**chioggia**	35.00	33.80	66 857 000	2 269 000	2 334 000	**0.21**	**0.79**	**0.11**
29-30/03/2003	**chioggia**	35.40	33.90	101 479 000	3 551 000	3 476 000	**0.64**	**0.36**	**0.49**
15-16/07/04	**chioggia**	35.91	34.90	88 260 000	3 139 000	3 106 000	**0.52**	**0.48**	**0.37**

RESIDUAL FLOW AND INDEX OF RIVER CONTAMINATION



AT LIDO INLET



CONCLUDING REMARKS

The Venice storm surge barriers are a good example of artificial device for flood protection without impacting the sensitive hydro-morphological system

A monitoring system has been set up for controlling the process

In order to improve the reability of the survey system a wi-fi sensor communication system will be tested