SER 2018 EUROPE | Restoration in the Era of Climate Change

LIFE LAGOON REFRESH. Ecological restoration in Venice Lagoon (Italy): concrete actions supported by numerical modelling.

Feola A., Matticchio B., Canesso D., Volpe V., Lizier M., Sfriso A., Bonometto A., Ferla M., Boscolo Brusà R.

LIFE16NAT/IT/000663 - Coastal lagoon habitat (1150) and species recovery by restoring the salt gradient increasing fresh water input*

ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale
Sistema Nazionale per la Protezione dell'Ambiente
Regione del Veneto
Ministero Infrastrutture e Trasporti Provveditorato Interregionale OO.PP. Veneto-Trentino Alto-Adige Friuli Venezia Giulia
Università Ca'Foscari Venezia
IPROS Ingegneria Ambientale

PARTNERSHIP, BUDGET AND DURATION

Coordinator

ISPRA – Italian National Institute for Environmental Protection and Research

Partners

Veneto Region - Environmental Protection Department

Interregional Superintendency for Public Works in Veneto, Trentino Alto Adige, Friuli Venezia Giulia

University Cà Foscari of Venice

IPROS Environmental Engineering s.r.l

Budget info

Total amount: 3’315’130 Euro

Eligible budget: 3’286’630 Euro

% EC Co-funding: 74,13% of total eligible budget

Duration

Start: 01/09/2017

End: 31/08/2022

Location

Venice Lagoon

ITALY

PROJECT BACKGROUND: DIFFERENT NATURAL AND ANTHROPOGENIC PRESSURES

First modern hydrographic map based on surveys of 1809 and 1811

SEVERE REDUCTION OF THE ECOTONAL TRANSITION ZONE BETWEEN LAND AND LAGOON, CHARACTERIZED BY A MARKED SALINE GRADIENT

D'Alpaos, 2010. *Morphological evolution of the Venice Lagoon through historical and hydrographic maps*

Hydrographic map based on surveys of 2000

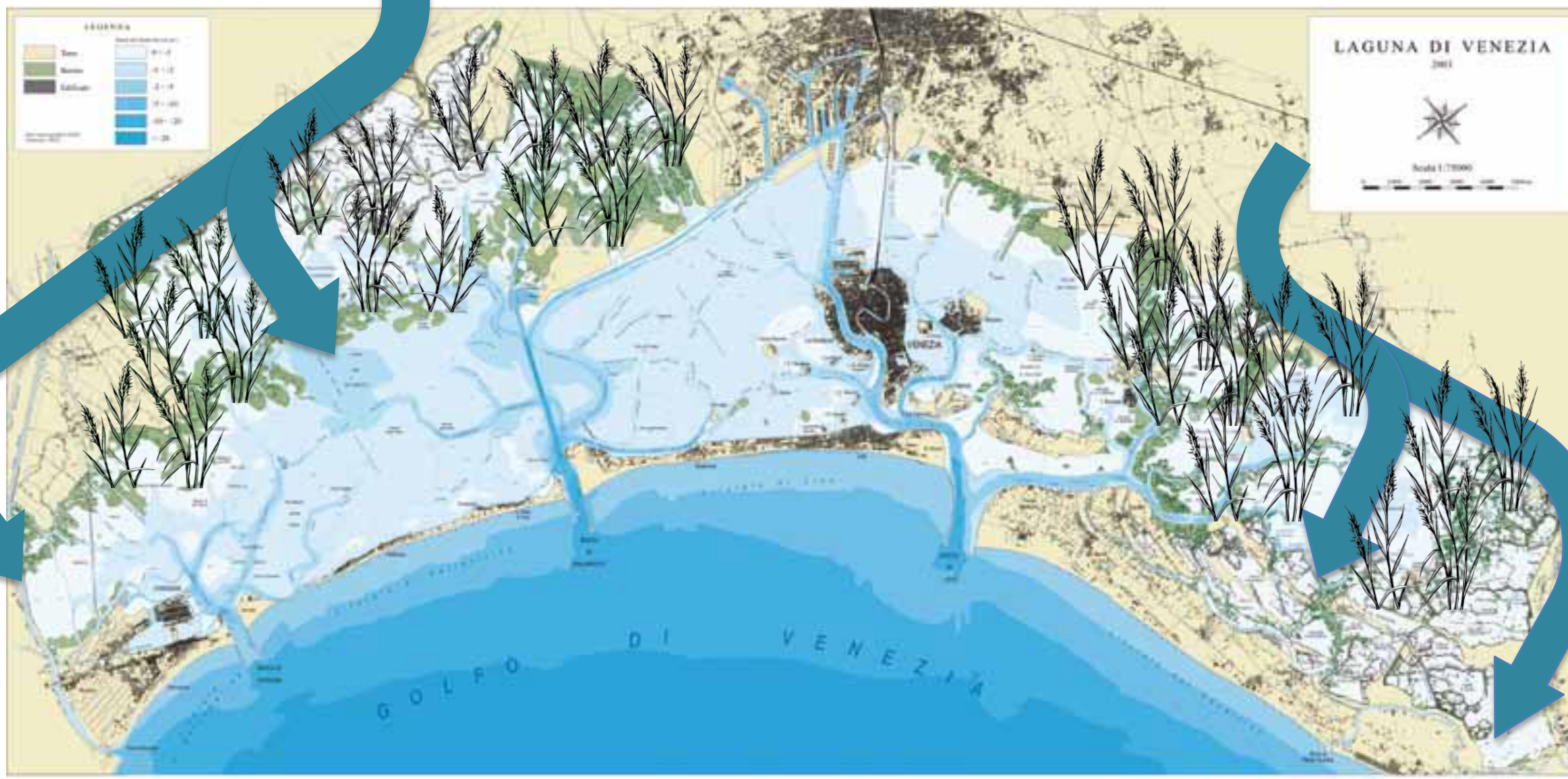
DIFFERENT NATURAL AND ANTHROPOGENIC PRESSURES

PROJECT BACKGROUND: RIVERS DIVERSION

VENICE LAGOON: 550 Km^2

SALT MARSHES: 170 Km^2 (1901)

47 km^2 (2003)



Hydrographic map based on surveys of 2000

RIVERS DIVERSION → **REED BED STRONG REDUCTION**

PROJECT MAIN OBJECTIVES

RECREATE THE **TYPICAL OLIGO-MESOHALINE** ENVIRONMENTS OF ESTUARINE TYPE

- to improve the **Degree of Conservation of Habitat 1150** * - Coastal lagoons in the Northern Lagoon of Venice, SCI IT3250031
- to reduce the **degree of eutrophication**, thanks to reed phytoremediation function;
- to improve the **status of bird species** included in annex I of Dir. 2009/147/EC, that use the reed environment during the winter period and /or for breeding, foraging or nesting;
- to increase the **presence of fish species** attracted by the presence of low-salinity environments;

POLICY IMPLICATIONS

- **"HABITAT DIRECTIVE" 92/43/CEE / "BIRDS DIRECTIVE" 2009/147/EC**

  improvement of **conservation degree of habitat and species** of Community interest

- **"WATER FRAMEWORK DIRECTIVE" 2000/60/EC**

  improvement of the trophic state of the habitat 1150* in order to contribute to the **achievement of the good Ecological status** in two water bodies within the Venice lagoon

- **2020 BIODIVERSITY STRATEGY**

  restoration of salt gradient and reed bed surfaces in order to contribute to the **increase of biodiversity** in the project area. Increasing of species included in Habitat and Birds Directives and other bird species of special conservation interest

PROJECT KEY ACTIONS

- ✓ diversion of a **freshwater flow** (1.000 l/s) from the river Sile into the lagoon;
- ✓ restoration of the **intertidal morphology** to sustain the reed development;
- ✓ planting of ***Phragmites australis*** and transplantation of ***Ruppia cirrhosa*** and ***Zostera noltei****;*
- ✓ establishment of a protected zone of 70 ha in order to manage/reduce hunting and fishing pressure;
- ✓ **monitoring** of the project impact;
- ✓ actions of **dissemination** and **replication** of project's results.

LEARNING FROM RESULTS
GENERATING EVIDENCE
SHARING APPROACH

NUMERICAL MODELLING AS SUPPORTING TOOL

NUMERICAL MODELLING WAS USED AS A SUPPORTING TOOL:

- TO REACH PROJECT GOALS
  - TO DEFINE THE EXTENSION OF THE AREA OF INFLUENCE (1900 ha)
  - TO DEFINE THE MOST SUITABLE PROJECT CONFIGURATION IN TERMS OF SALINITY DIFFUSION AND HYDRAULIC EFFECTS

2D- 3D MODEL OF LAGOON

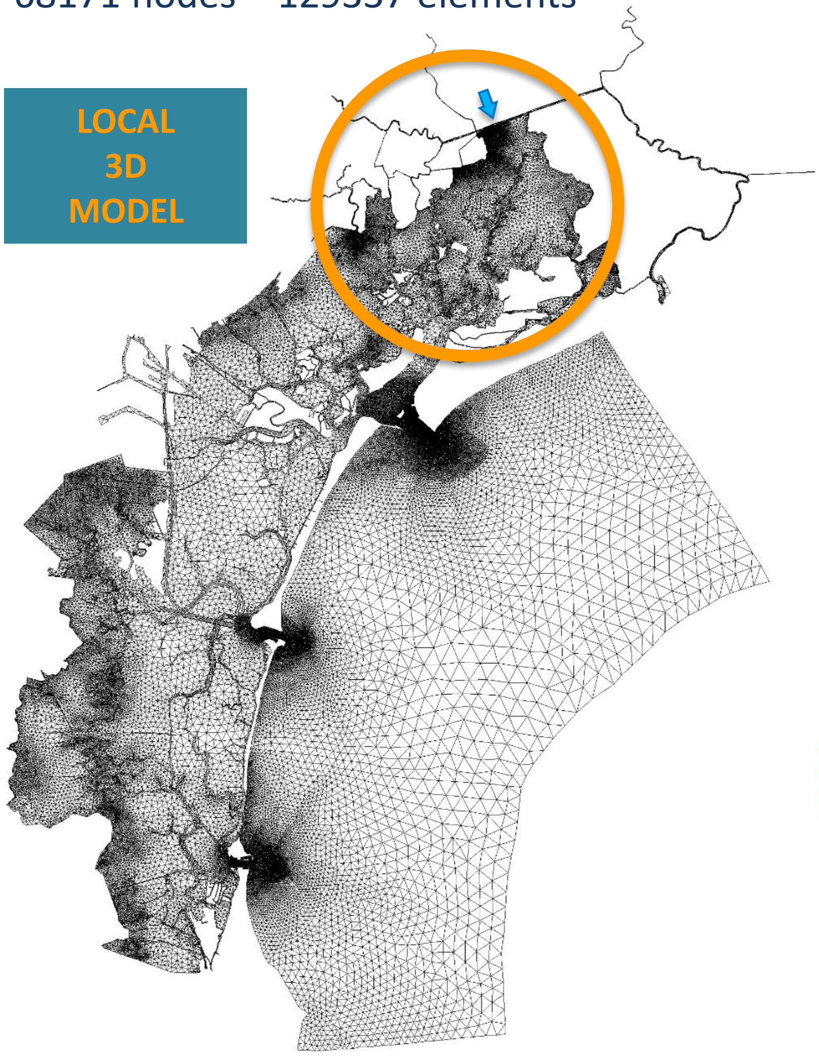
- TO VERIFY PROJECT POSSIBLE IMPACTS ON SILE RIVER (WATER LEVEL, DISCHARGE, SALINE WEDGE INTRUSION)

2D- 3D MODEL OF RIVER SYSTEM

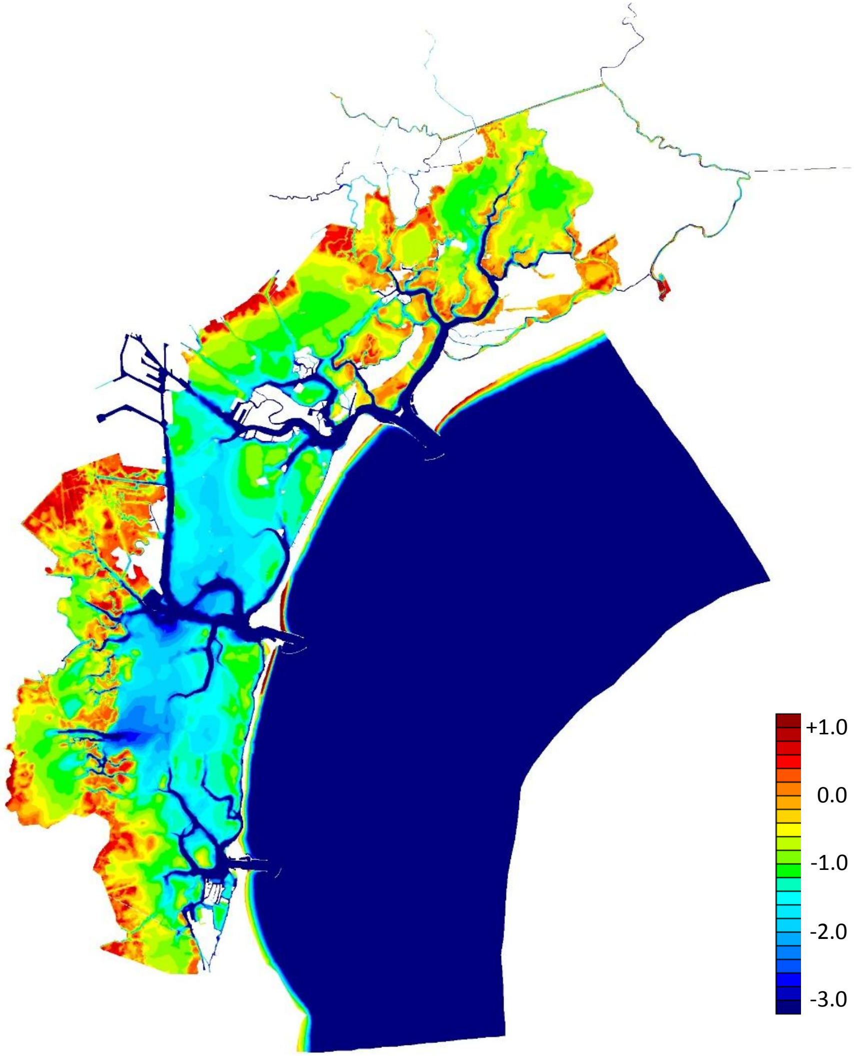
DETAILS OF SETUP, CALIBRATION AND RESULTS WILL BE PRESENTED

2D HYDRODINAMIC MODEL FOR THE ENTIRE VENICE LAGOON

Mesh for the entire lagoon
68171 nodes – 129337 elements



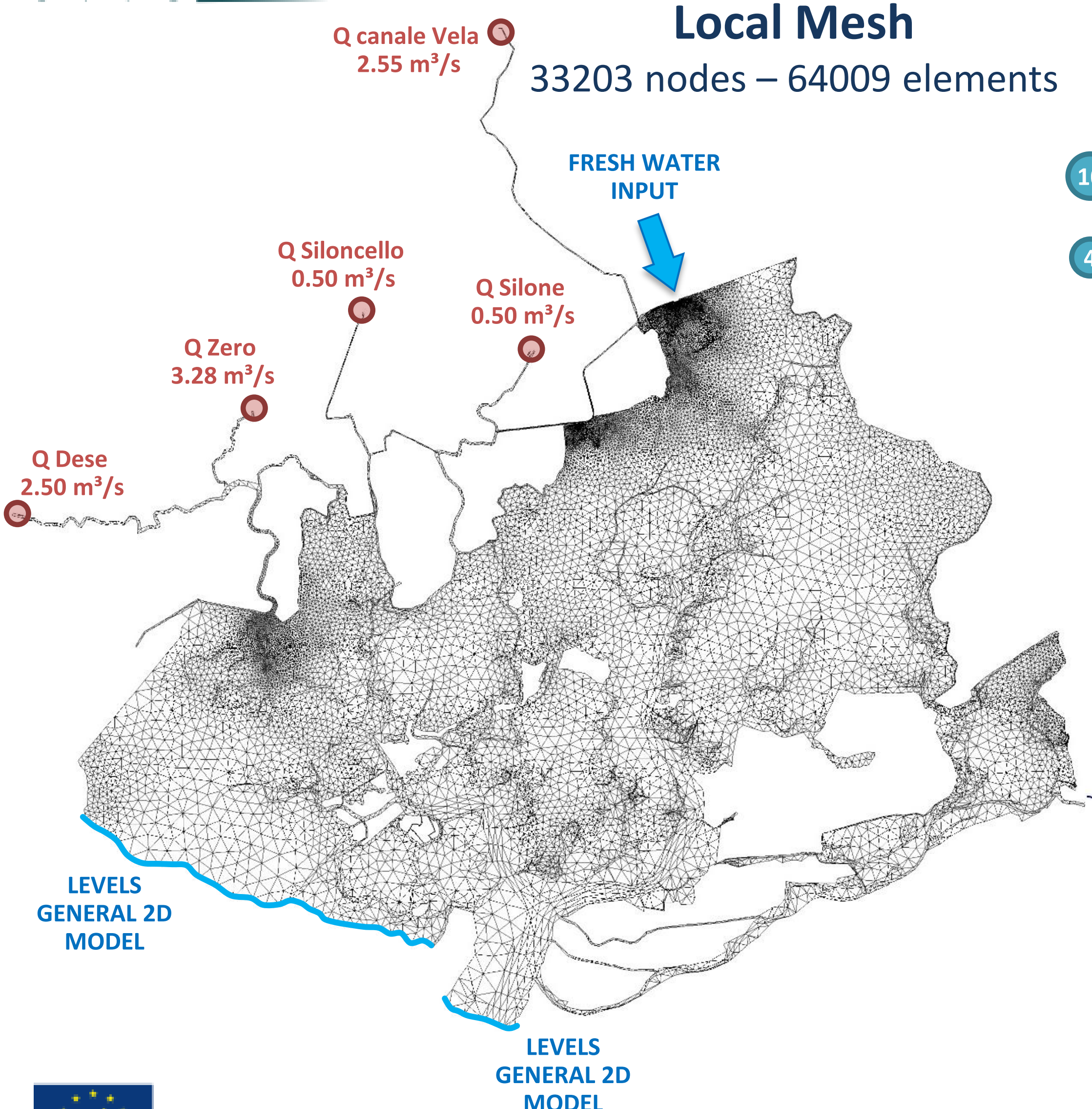
Bathymetry (m s.l.m.)



3D HYDRODINAMIC MODEL
NOTHERN PART OF THE VENICE LAGOON

Local Mesh

33203 nodes – 64009 elements

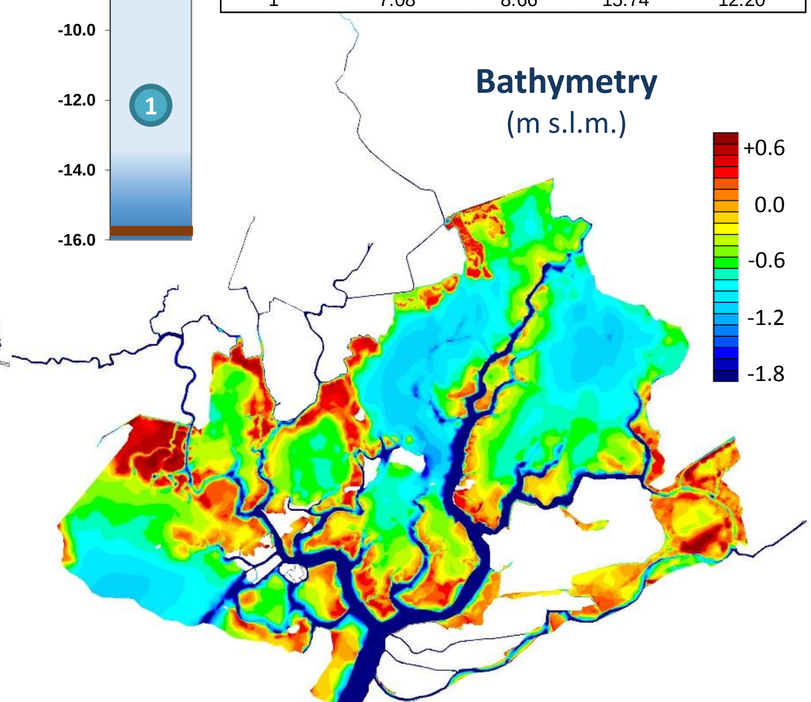


Vertical layers

LAYER N	THICK. (m)	FROM (m)	TO (m)	MEAN DEPTH (m)
10	0.16	0.00	0.16	0.08
9	0.16	0.16	0.31	0.24
8	0.16	0.31	0.47	0.39
7	0.16	0.47	0.63	0.55
6	0.31	0.63	0.94	0.79
5	0.63	0.94	1.57	1.26
4	0.79	1.57	2.36	1.97
3	1.57	2.36	3.94	3.15
2	4.72	3.94	8.66	6.30
1	7.08	8.66	15.74	12.20

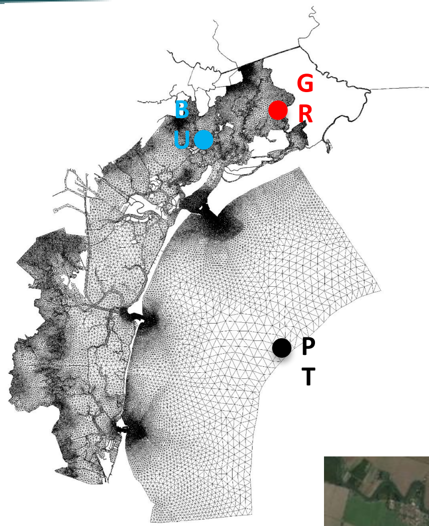
Bathymetry

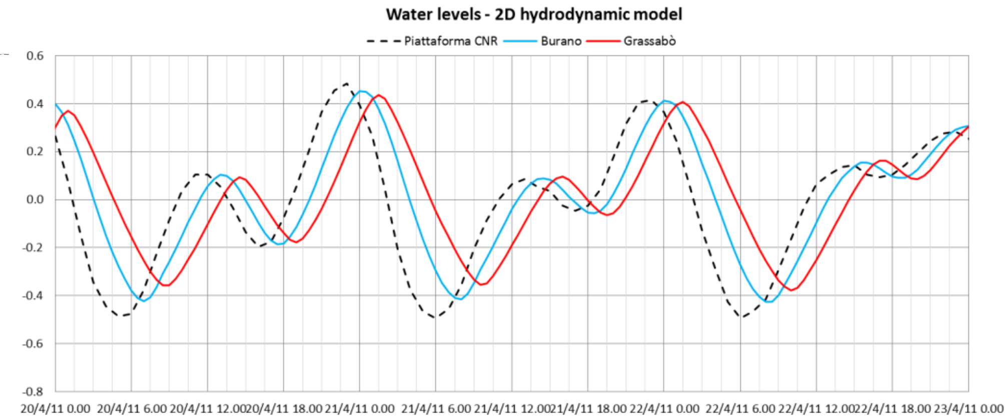
(m s.l.m.)



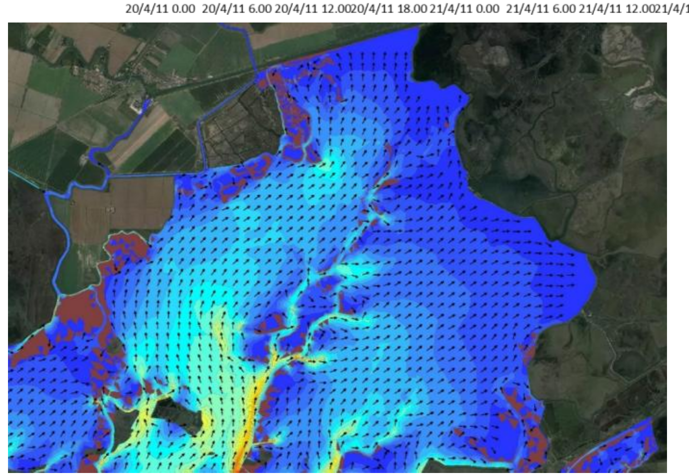
HYDRODINAMIC MODEL: TYPE OF RESULTS

✓ WATER LEVEL





✓ CURRENT SPEED

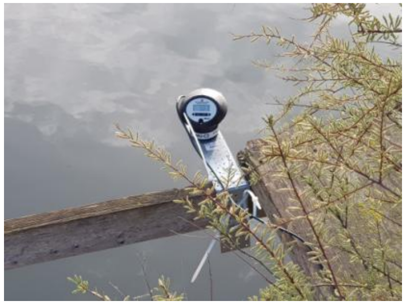


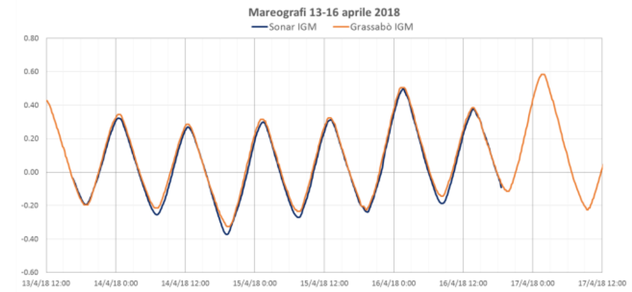
✓ SALINITY

NUMERICAL MODELS NEED TO BE CALIBRATED

WATER LEVEL

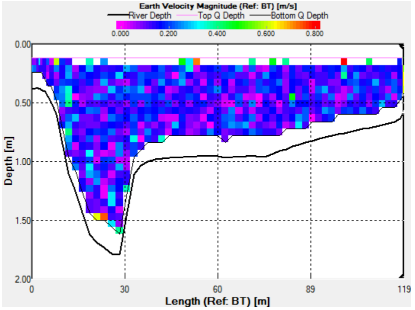
TIDE LEVEL STATIONS

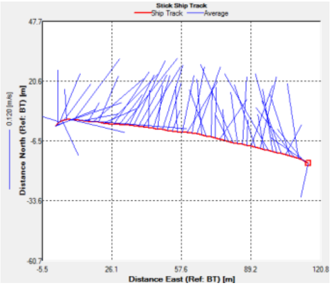




CURRENT SPEED

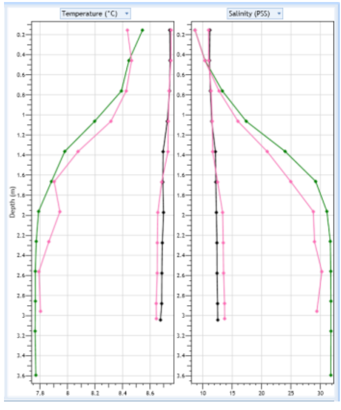
ADCP FIELD CAMPAIGNS





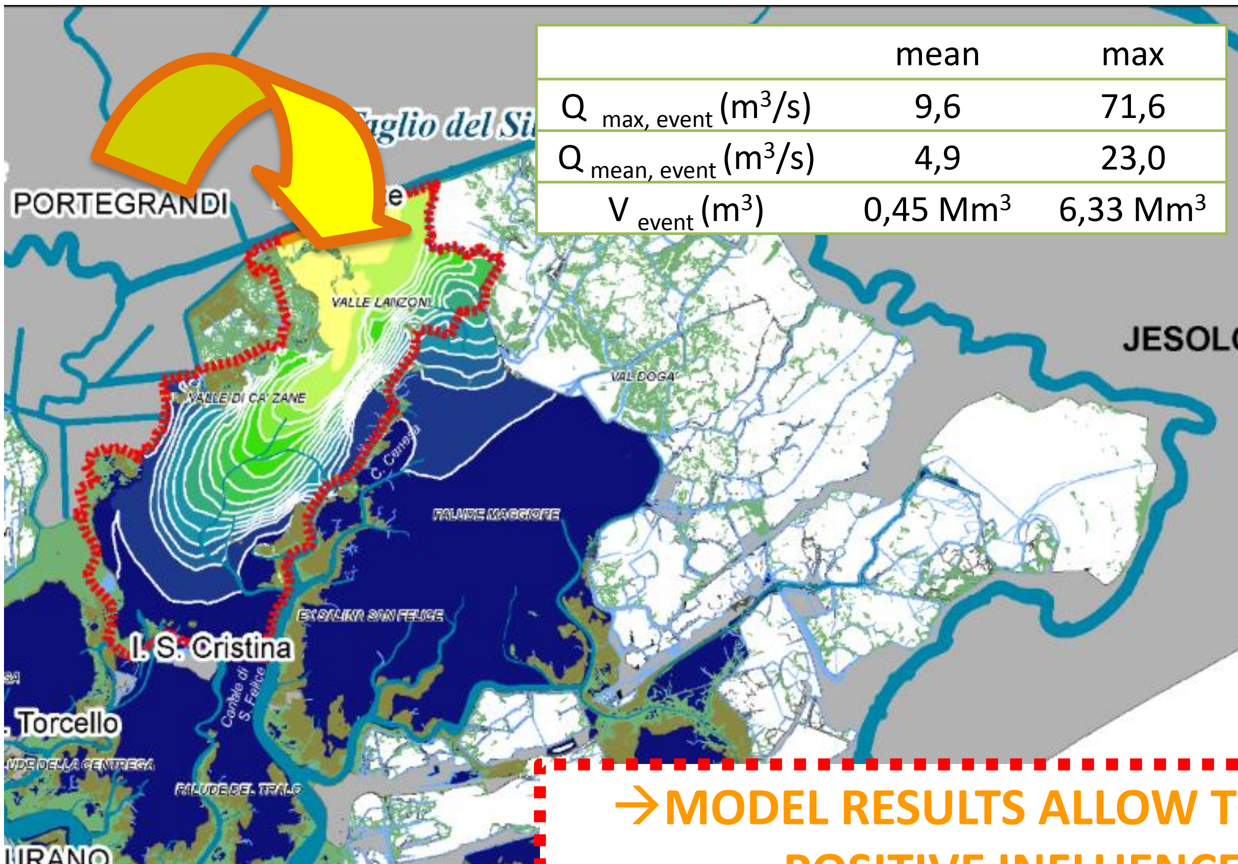
SALINITY

CTD FIELD CAMPAIGNS -FIXED STATIONS



NUMERICAL MODEL USED TO DEFINE THE EXTENSION OF THE AREA OF INFLUENCE

CURRENTLY, DURING FLOOD EVENTS, **WATER SPILLS FROM SILE RIVER INTO THE LAGOON**, WITHOUT BUFFER ZONE ABLE TO REDUCE NUTRIENT LOADS



	mean	max
$Q_{max, event}$ (m^3/s)	9,6	71,6
$Q_{mean, event}$ (m^3/s)	4,9	23,0
V_{event} (m^3)	0,45 Mm^3	6,33 Mm^3

THE PROJECT WILL INCREASE THE ENVIRONMENTAL SUSTAINABILITY OF EXISTING FLOOD PROTECTION INFRASTRUCTURES (SPILLWAY, FLOODS DIRECTIVE 2007/60/CE).

IN PARTICULAR, **RESTORATION OF MORPHOLOGY** AND **REED BEDS** WILL INCREASE THE **SELF-PURIFYING CAPACITY**, REDUCING THE RISK OF EUTROPHICATION.

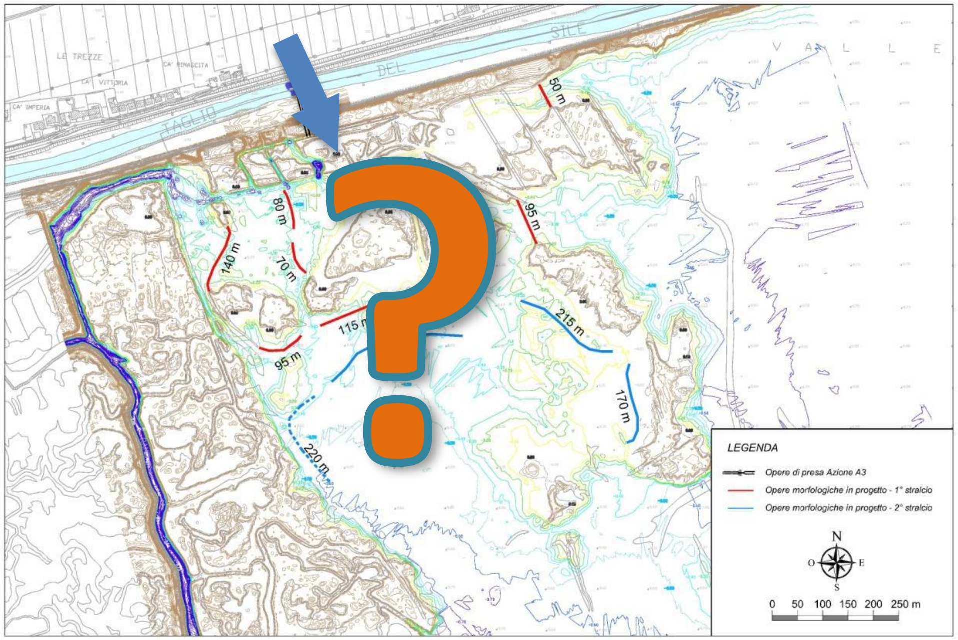
→MODEL RESULTS ALLOW TO IDENTIFY THE AREA OF POSITIVE INFLUENCE OF THE PROJECT

CONCRETE ACTIONS SUPPORTED BY NUMERICAL MODELLING

HYDRAULIC WORK

DIVERSION OF A FRESHWATER FLOW FROM THE SILE RIVER INTO THE LAGOON

WHICH DISCHARGE?



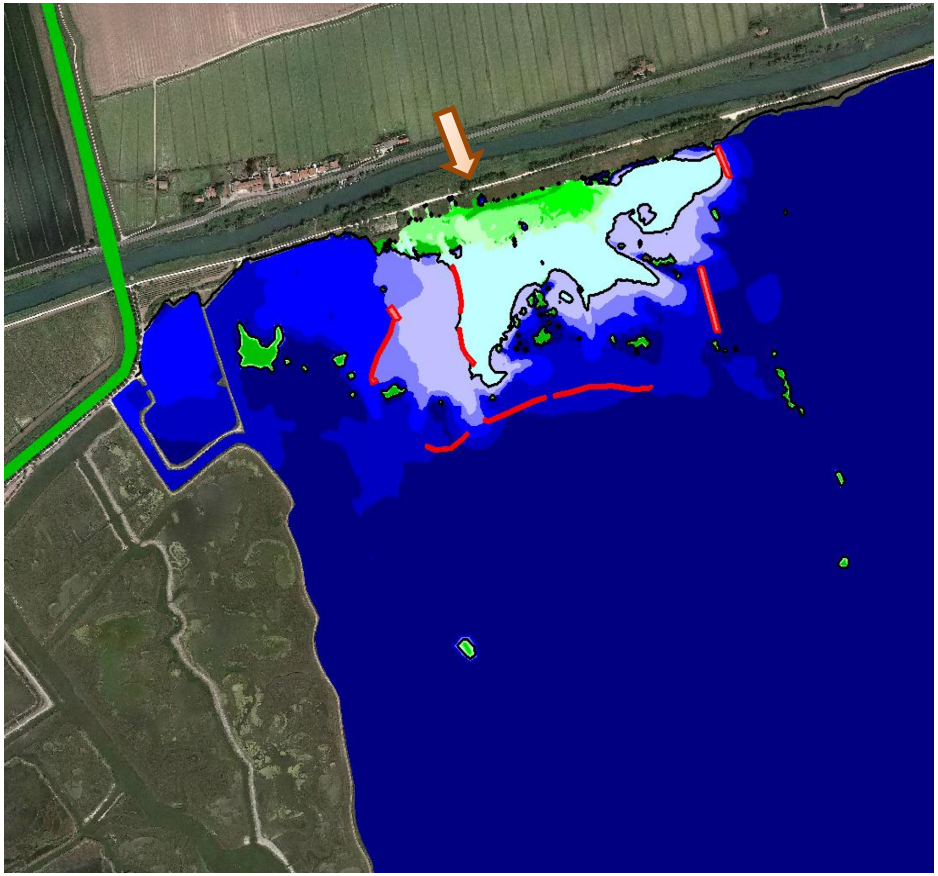
STRUCTURES PROPERLY ARRANGED IN ORDER TO SLOW DOWN THE FRESH WATER DISPERSION AND TO FAVOR THE REED DEVELOPMENT ACCORDING TO THE PROJECT CONFIGURATION

MORPHOLOGIC WORK

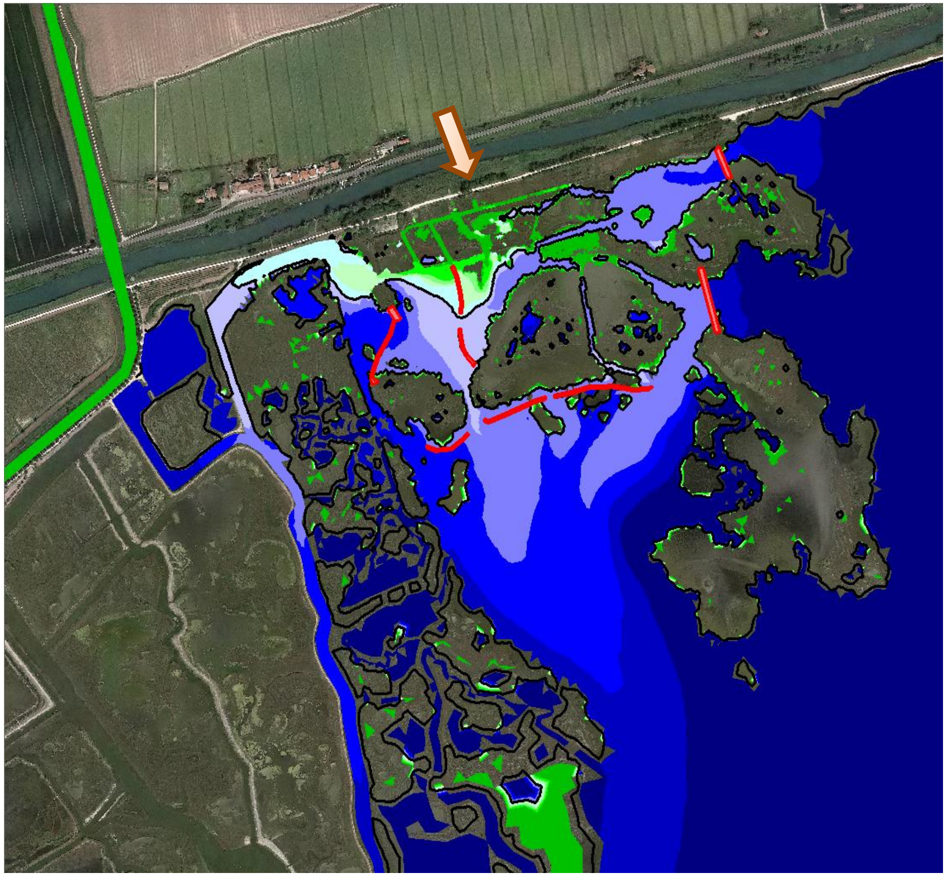
WHICH CONFIGURATION?

NUMERICAL MODEL USED TO EVALUATE DISCHARGE VARIATION IN TERMS OF SALINITY DIFFUSION

Configuration: BIO 1° step – Q = 300 l/s

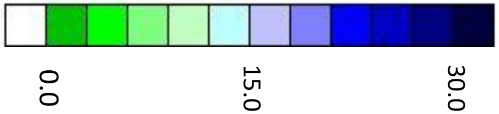


T = 242 time step (high tide) - H = 0.38 m a.s.l.



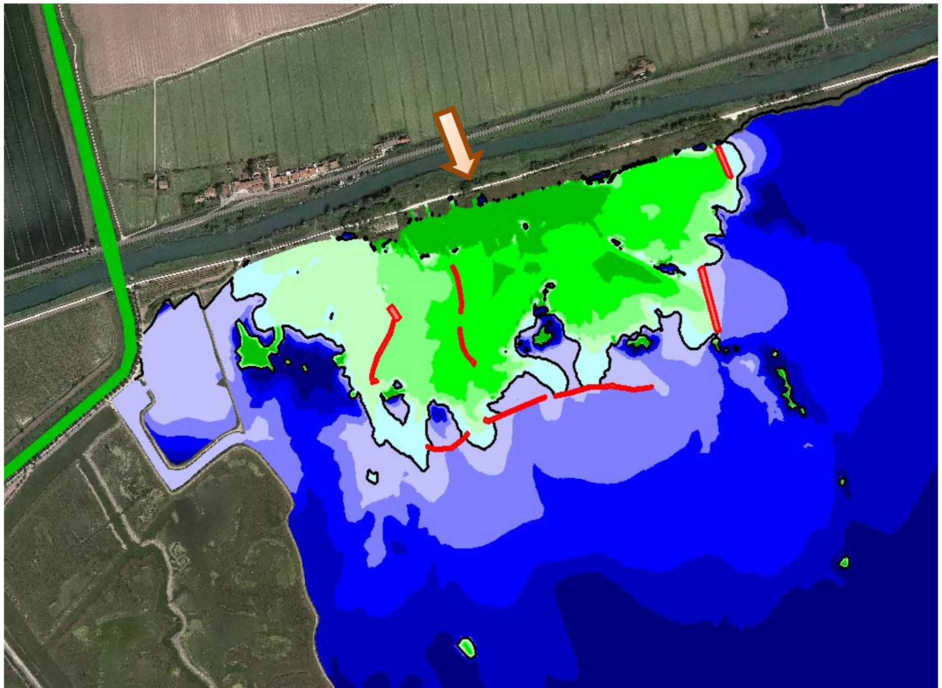
T = 249 time step (low tide) – H = -0.16 m a.s.l.

Salinity
(PSU)



NUMERICAL MODEL USED TO EVALUATE DISCHARGE VARIATION IN TERMS OF SALINITY DIFFUSION

Configuration: BIO 1° step – Q = 1000 l/s



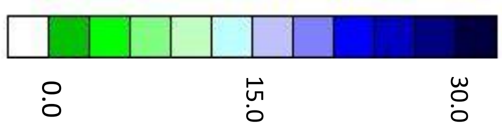
EXPECTED RESULTS:

- WATER SALINITY: FROM >30 (ANNUAL MEAN) TO <5 PSU (5 ha); <15PSU (25 ha); <25PSU (70 ha);
- REED BED SURFACE FROM 30 TO 50 HA AT THE END OF THE PROJECT (60 ha 5 YEARS AFTER)

T = 242 time step (high tide) - H = 0.38 m a.s.l.

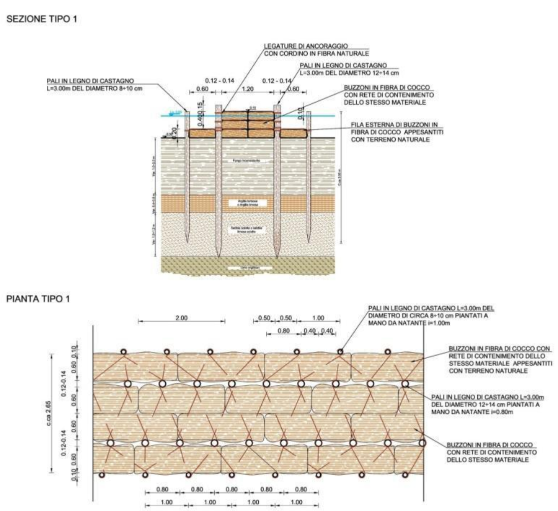
T = 249 time step (low tide) – H = -0.16 m a.s.l.

Salinity
(PSU)

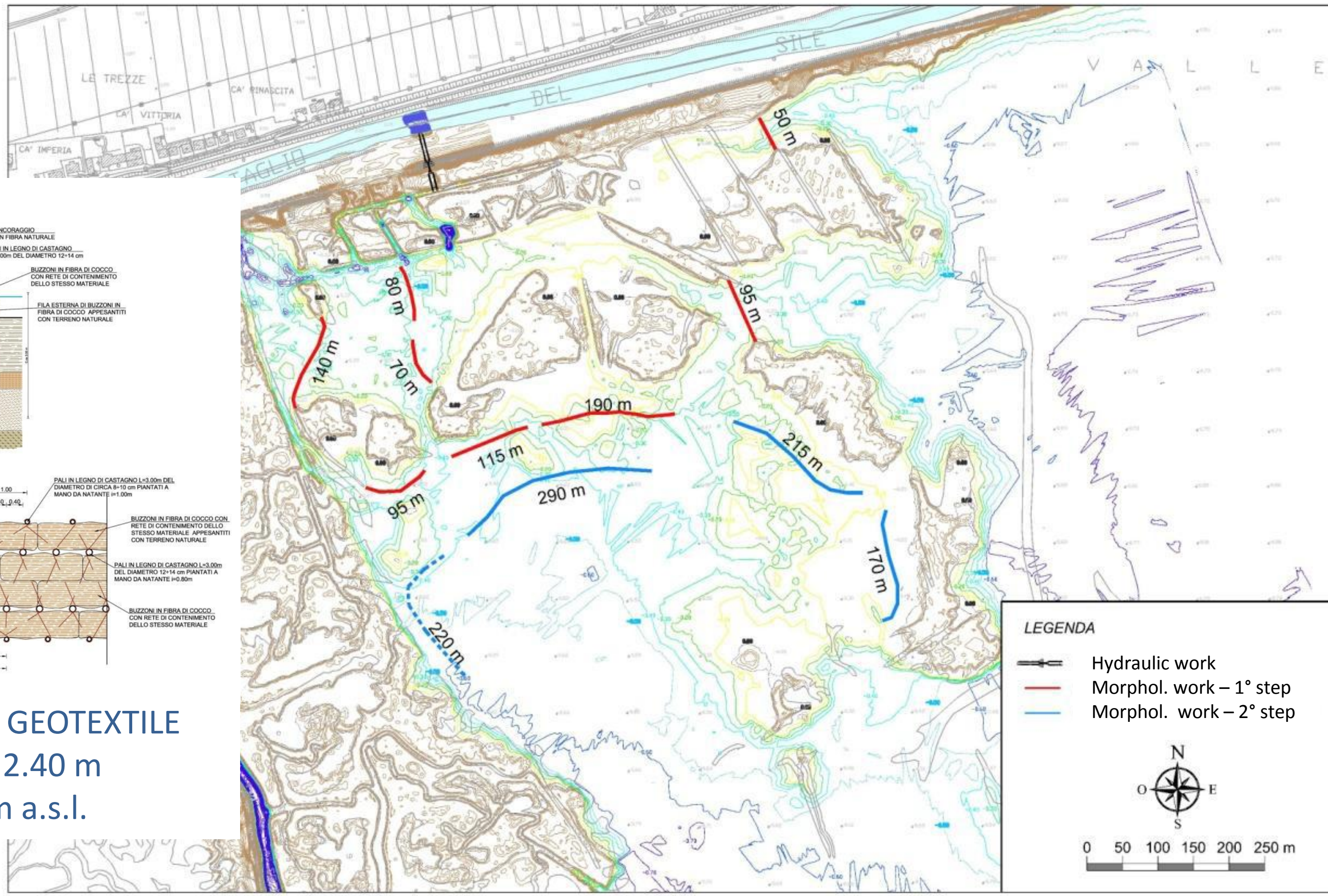


MORPHOLOGIC WORK

RESTORATION OF THE INTERTIDAL MORPHOLOGY THROUGH THE IMPLEMENTATION OF STRUCTURES MADE BY BIODEGRADABLE GEOTEXTILE

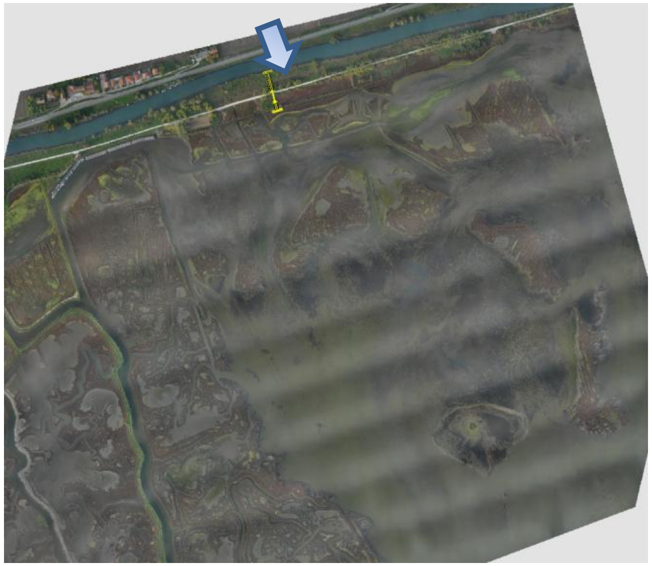


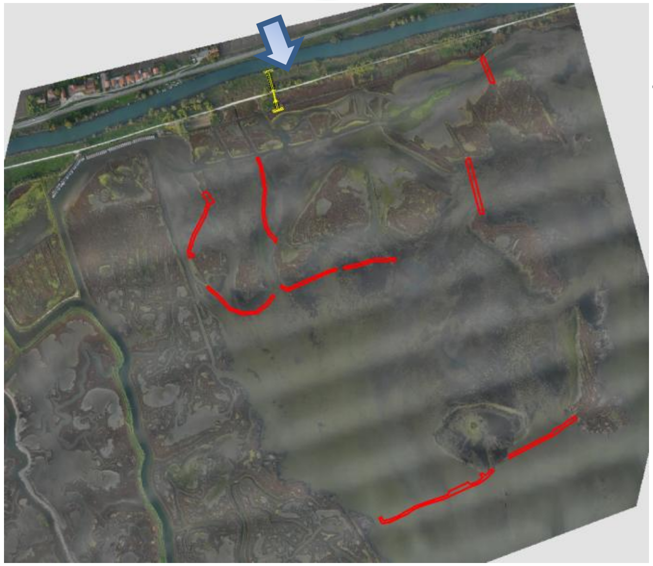
BIODEGRADABLE GEOTEXTILE
Dimension: 2.40 m
Top: 0.15 m a.s.l.



MORPHOLOGIC WORK
PROJECT SETUP – DIFFERENT CONFIGURATIONS

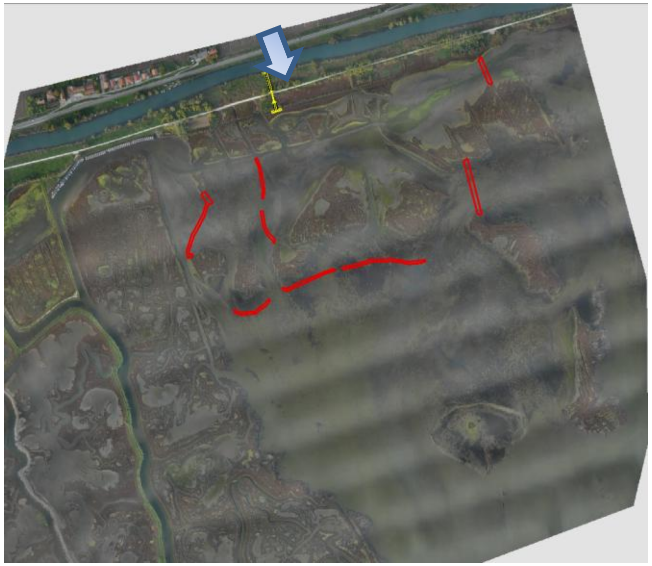
Configuration
ZERO

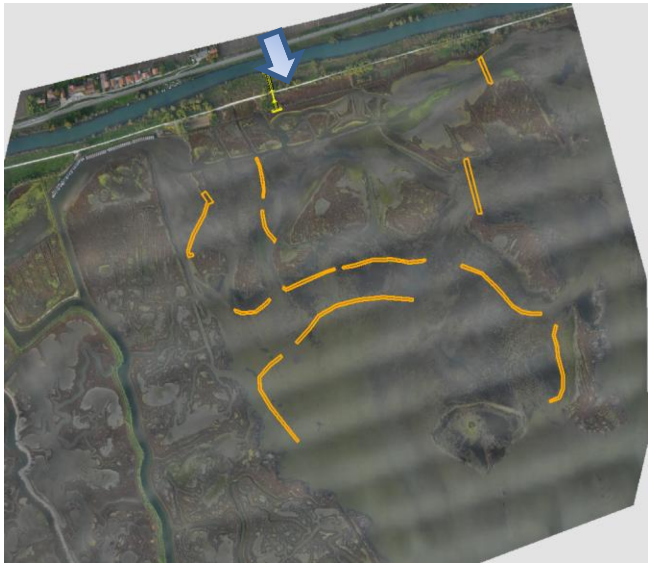




Configuration
C2
Top elevation:
+0.1 m a.s.l.

Configuration
BIO 1° step
Top elevation:
+0.1 m a.s.l.

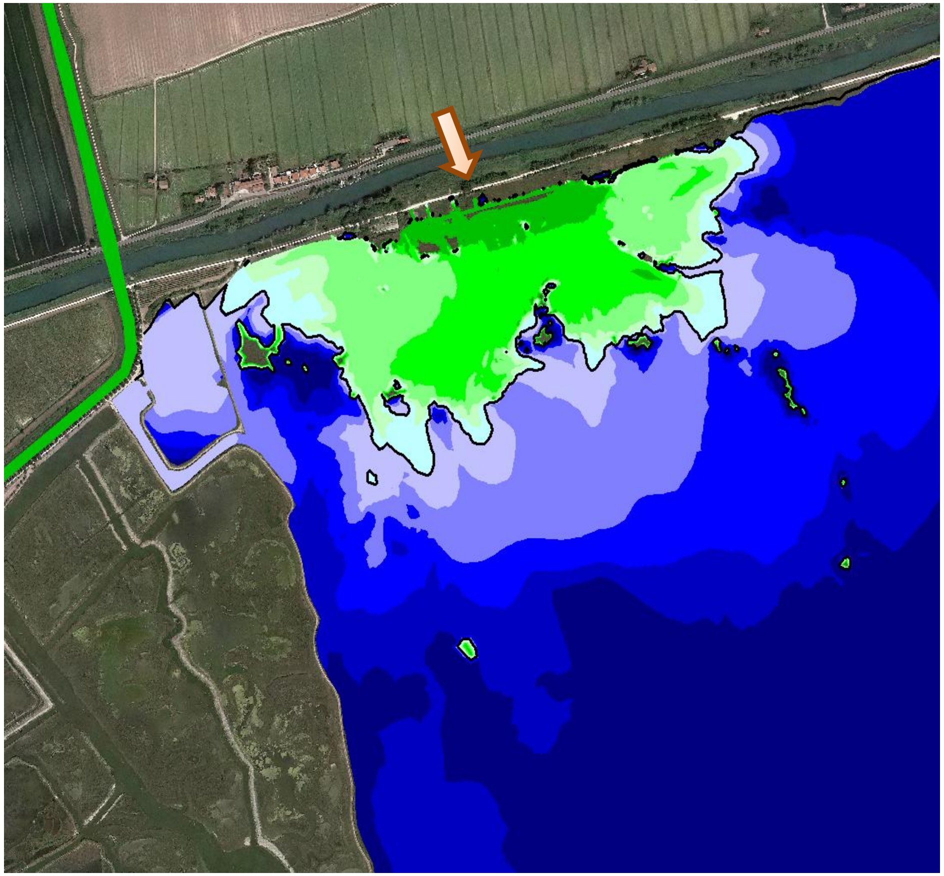




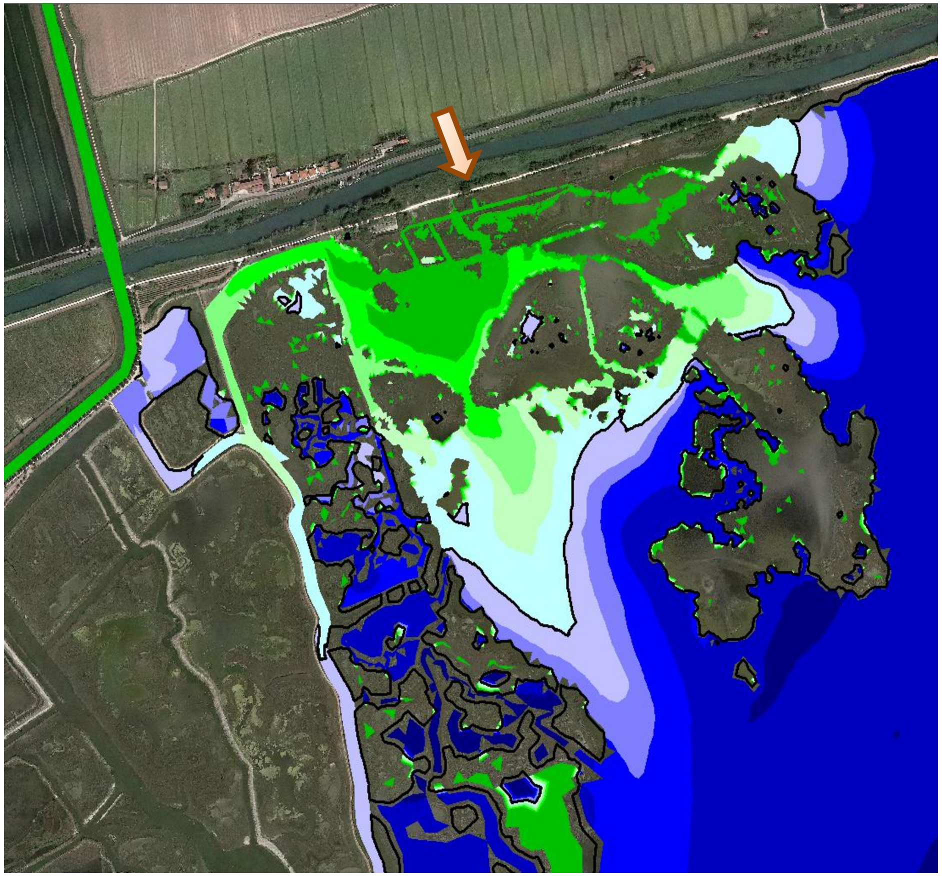
Configuration
BIO 2° step
Top elevation:
+0.1 m a.s.l.

NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION

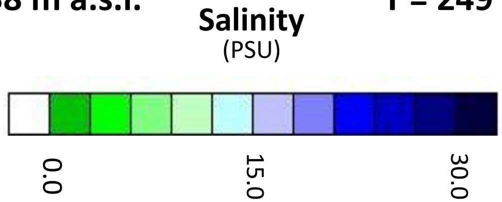
Configuration: ZERO – Q = 1000 l/s



T = 242 time step (high tide) - H = 0.38 m a.s.l.

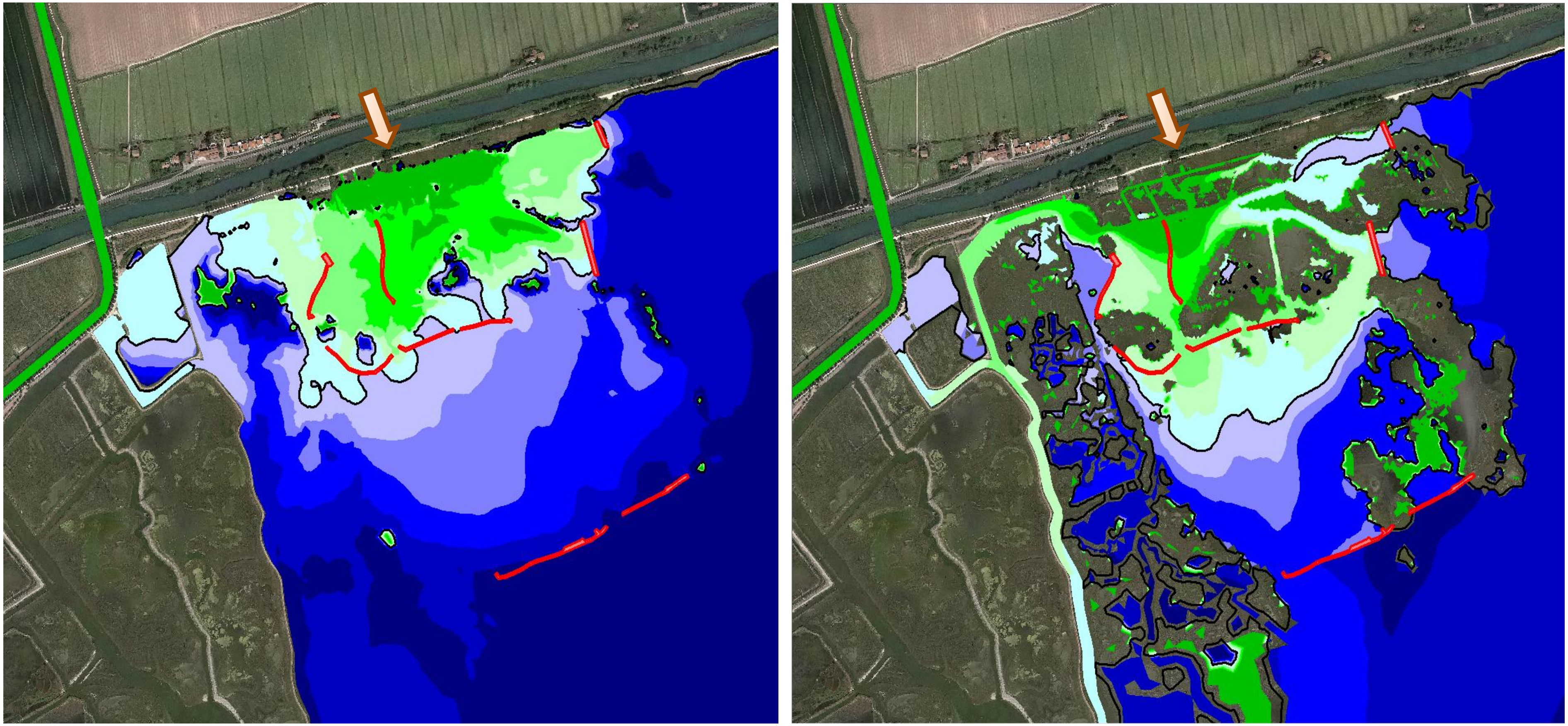


T = 249 time step (low tide) – H = -0.16 m a.s.l.



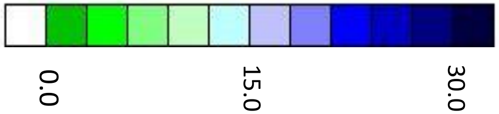
NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION

Configuration: C2 – Q = 1000 l/s



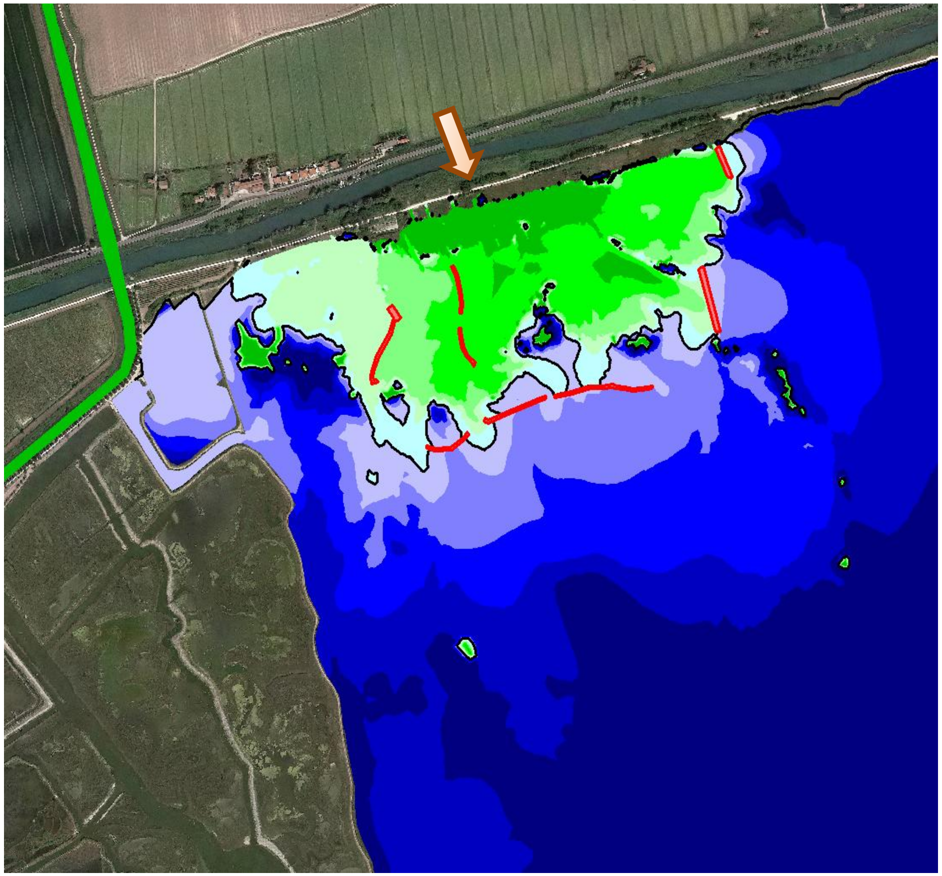
T = 242 time step (high tide) - H = 0.38 m a.s.l.

T = 249 time step (low tide) – H = -0.16 m a.s.l.



NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION

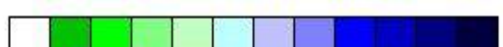
Configuration: BIO 1° step – Q = 1000 l/s



T = 242 time step (high tide) - H = 0.38 m a.s.l.

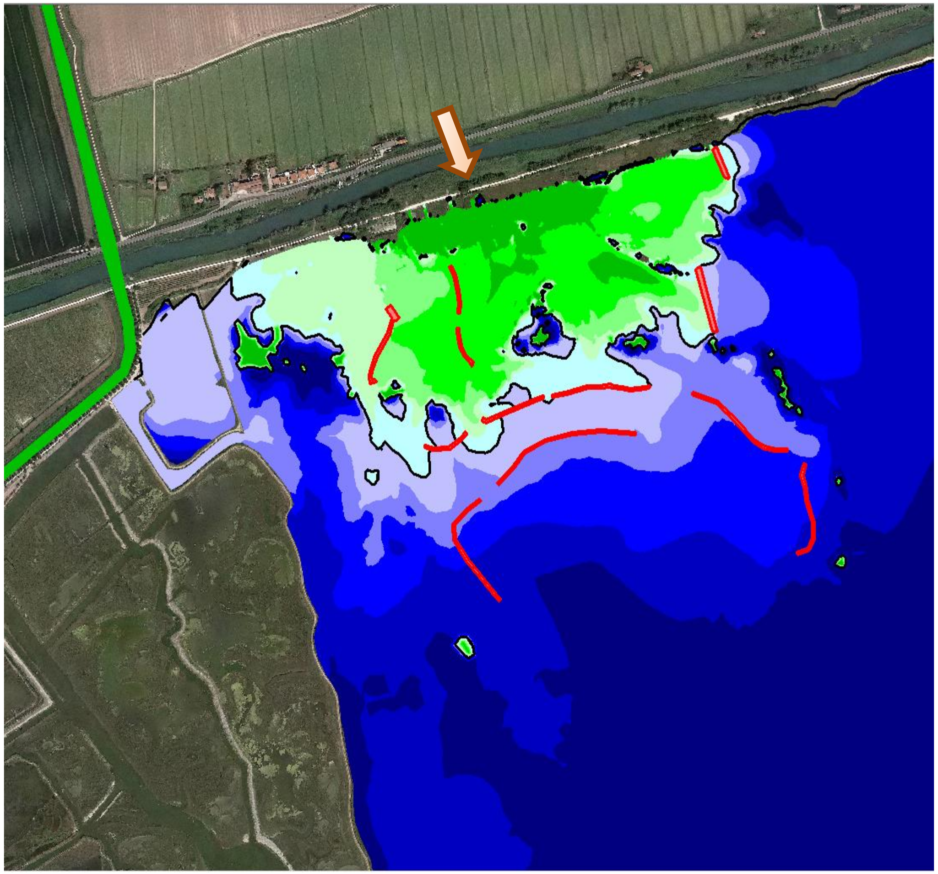
T = 249 time step (low tide) – H = -0.16 m a.s.l.

Salinity
(PSU)



NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION

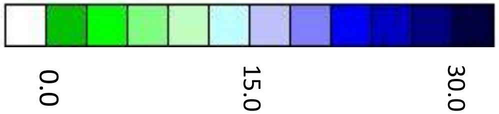
Configuration: BIO 2° stralcio – Q = 1000 l/s



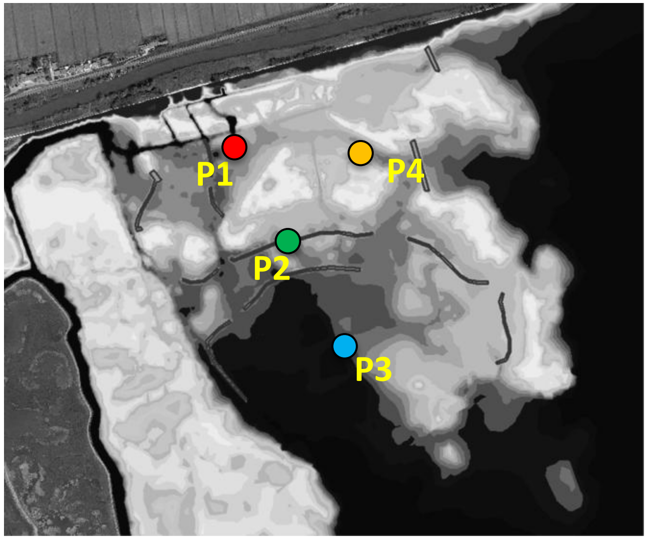
T = 242 time step (high tide) - H = 0.38 m a.s.l.

T = 249 time step (low tide) – H = -0.16 m a.s.l.

Salinity
(PSU)

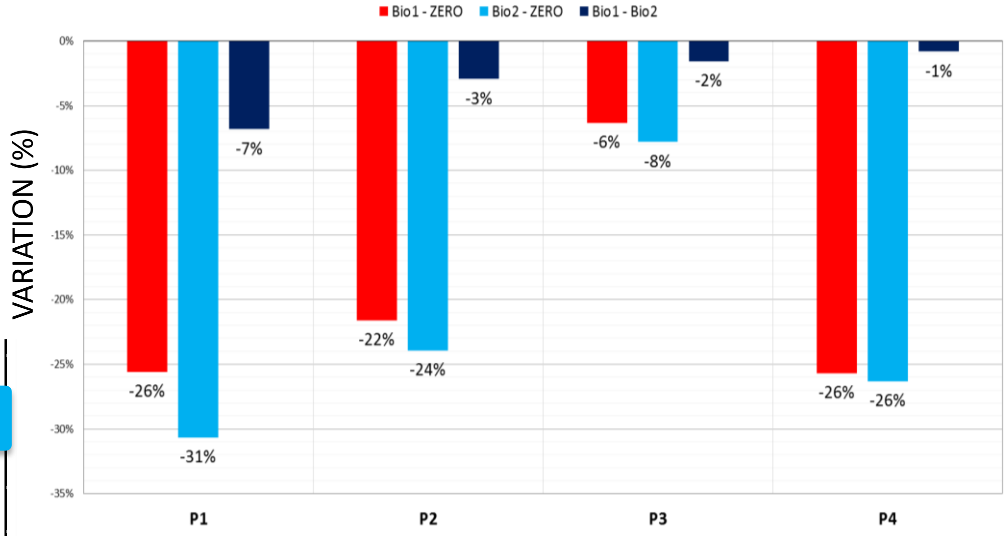


NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION



FRESH WATER DIFFUSION COMPARISON BETWEEN DIFFERENT PROJECT CONFIGURATIONS

SURFACE SALINITY - DAILY MEAN VALUES CONFIG ZERO VS CONFIG BIO2



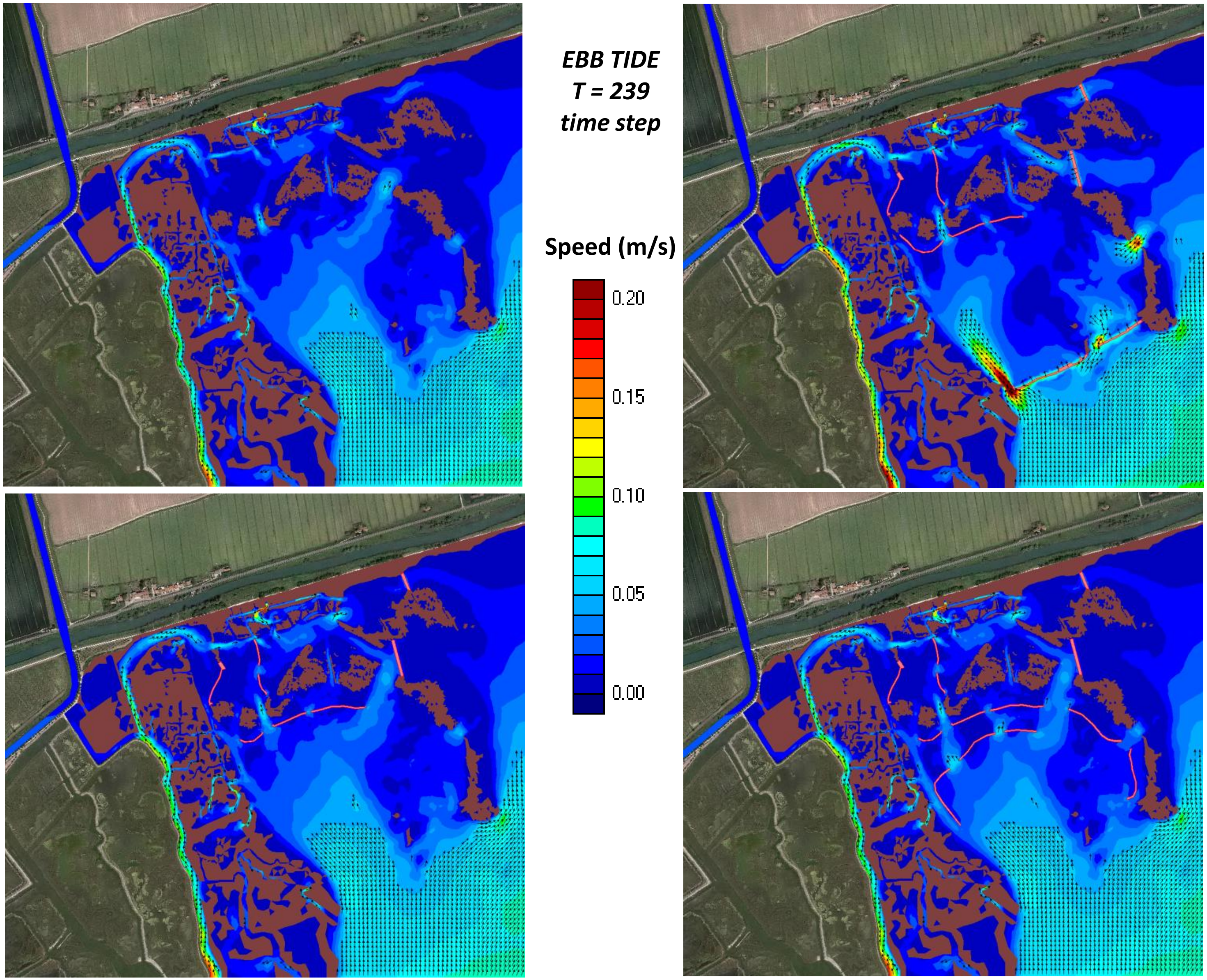
MEAN SALINITY ALONG VERTICAL PROFILE

	P1	*P2*	*P3*	*P4*
ZERO	1.8	16.6	23.2	8.6
Bio1	1.3	13.0	21.8	6.4
Bio2	1.2	12.6	21.4	6.3
delta % Bio1-ZERO	-26%	-22%	-6%	-26%
delta % Bio2-ZERO	-31%	-24%	-8%	-26%
delta % Bio2-Bio1	-7%	-3%	-2%	-1%

NUMERICAL MODEL USED TO COMPARE PROJECT MORPHOLOGICAL CONFIGURATION: CURRENT SPEED

Configuration ZERO

Configuration C2
Top elevation: +0.1 m a.s.l.



Configuration BIO 1° step
Top elevation: +0.1 m a.s.l.

Configuration BIO 2° step
Top elevation: +0.1 m a.s.l.

NUMERICAL MODEL USED TO VERIFY POSSIBLE IMPACTS

NUMERICAL MODEL USED TO VERIFY PROJECT POSSIBLE IMPACTS ON SILE RIVER

DRINKING WATER USE

IRRIGATION

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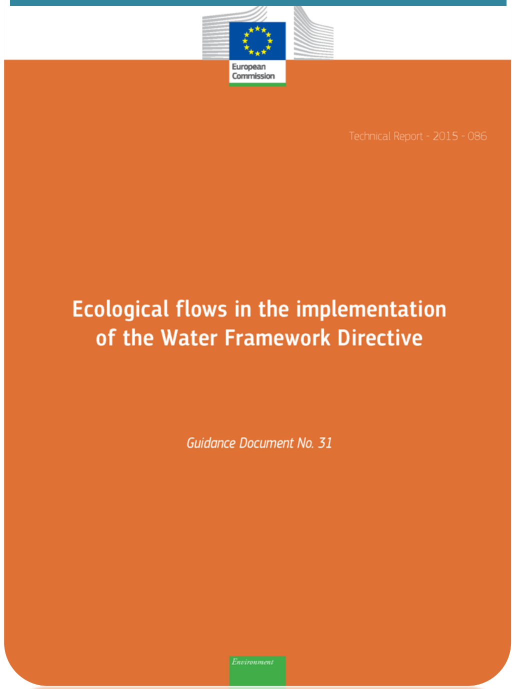
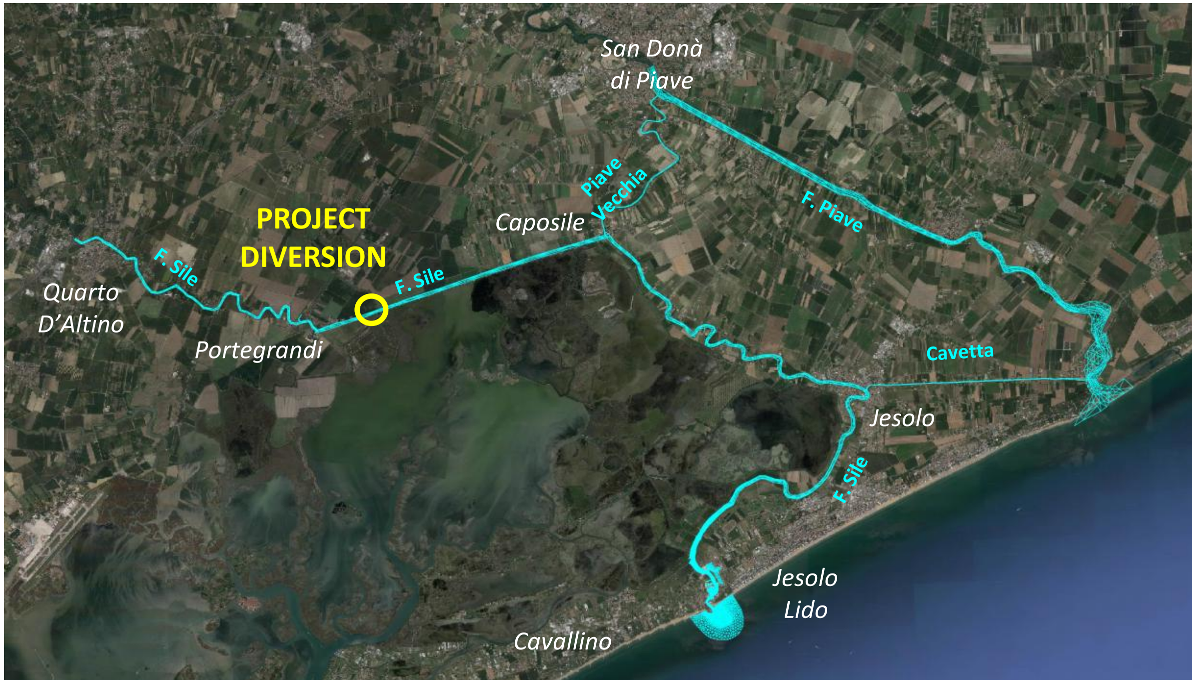
ECOLOGICAL ASPECTS

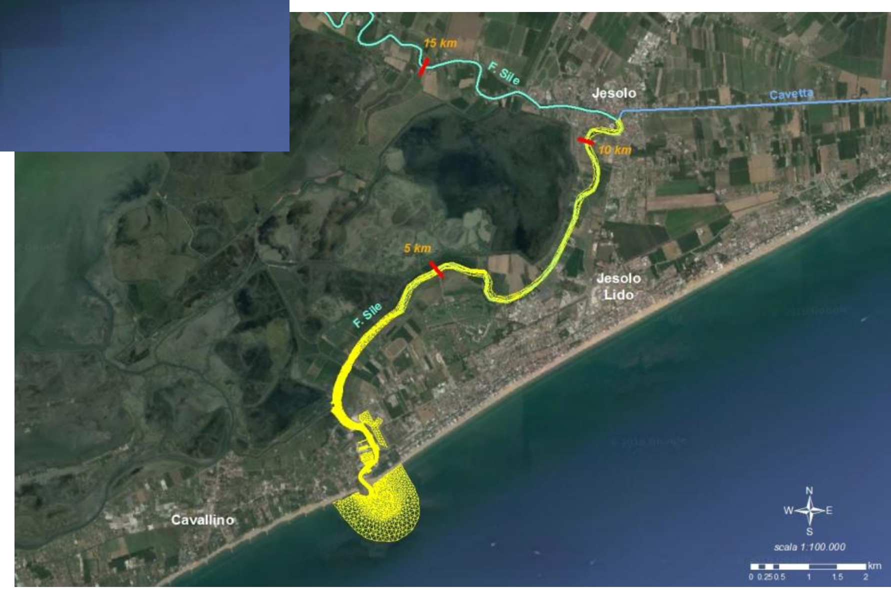


SOCIO-ECONOMIC
AND ENVIRONMENTAL CONCERN
OF DIFFERENT STAKEHOLDERS

SALINE WEDGE INTRUSION ON SILE RIVER
NUMERICAL MODELLING - SETUP



2D MODEL OF RIVER SYSTEM Sile-Piave-Piave Vecchia-Cavetta



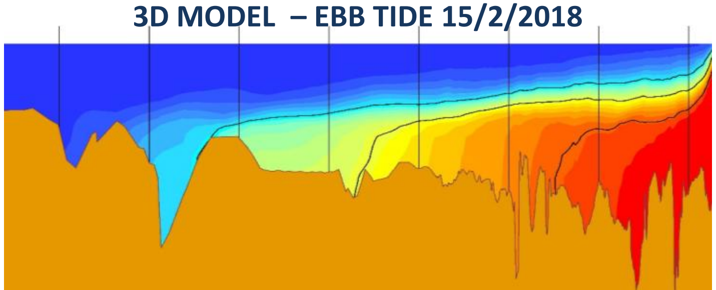
WATER LEVEL
DISCHARGE
SALINE WEDGE INTRUSION

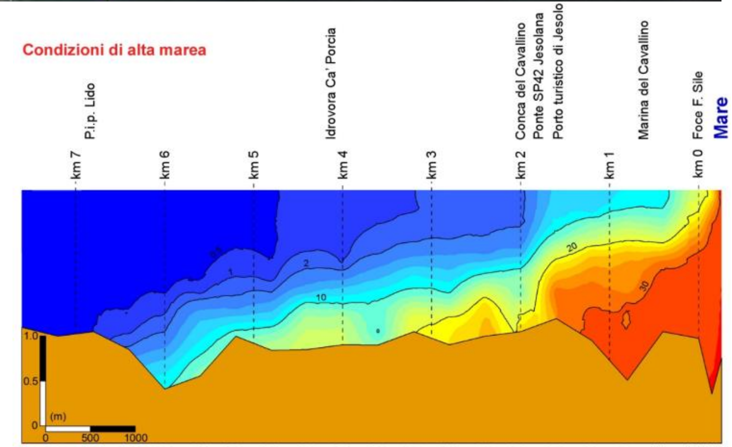
3D MODEL OF RIVER MOUTH

SALINE WEDGE INTRUSION ON SILE RIVER
NUMERICAL MODELLING – FIELD CAMPAIGNS

3D MODEL + FIELD CAMPAIGN (15/02/2018)
SIMULATION OF SALINE WEDGE INTRUSION

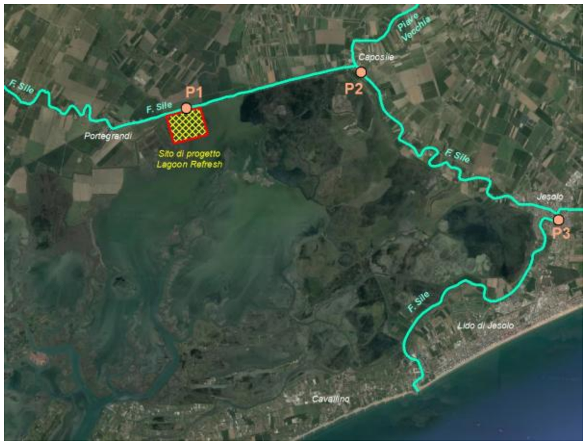
3D MODEL – EBB TIDE 15/2/2018





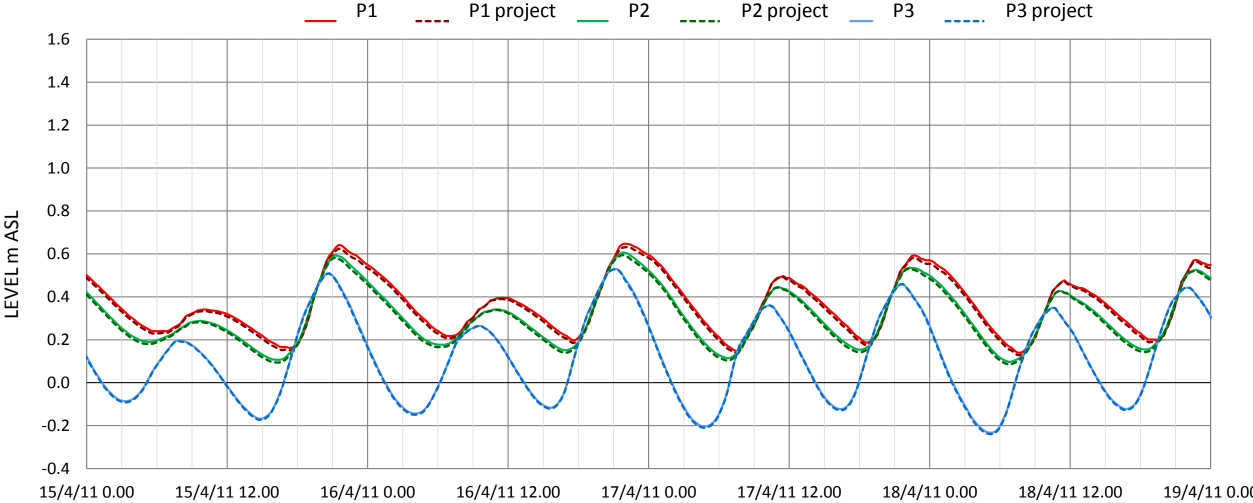
SALINE WEDGE INTRUSION ON SILE RIVER
NUMERICAL MODELLING - PROJECT EFFECTS EVALUATION

WATER LEVEL AND DISCHARGE VARIATIONS

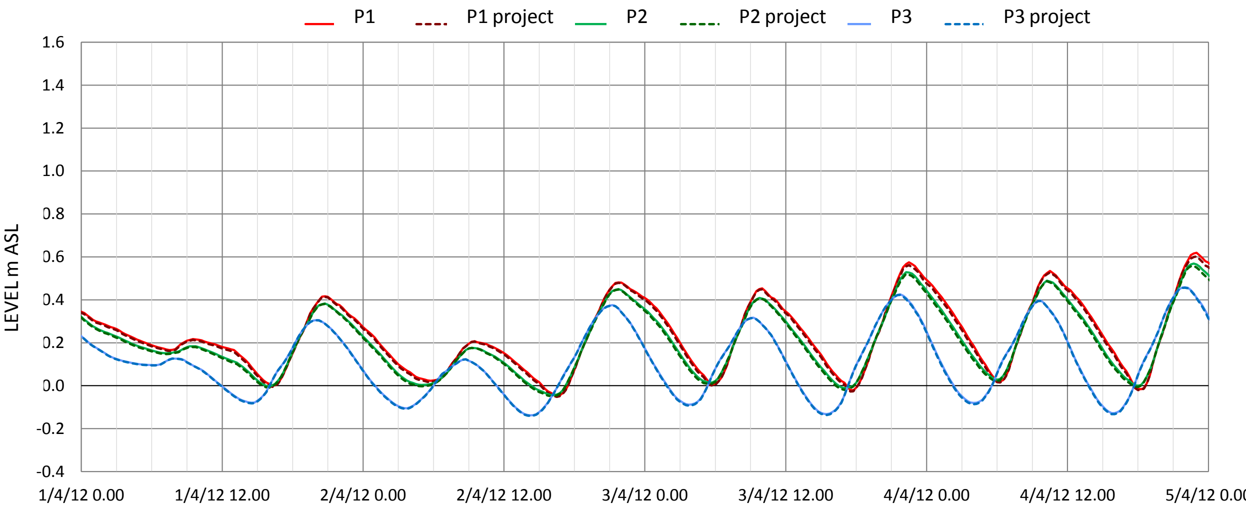


	section	Dry period	Normal period	Flood period
Level mean differences (m)	P1	0.007	0.010	0.019
	P2	0.006	0.009	0.017
	P3	0.003	0.004	0.006
Discharge mean differences (m^3s^{-1})	P1	0.8	1.0	1.6
	P2	0.8	1.0	1.5
	P3	0.6	0.7	1.0

Normal condition



Dry condition



CONCLUSIONS

- LIFE "LAGOON REFRESH" PROJECT AIMS TO **RECREATE THE TYPICAL OLIGO-MESOHALINE ENVIRONMENT OF ESTUARINE TYPE** AND TO **ACHIEVE RELATED ENVIRONMENTAL BENEFICIAL EFFECTS**
- **NUMERICAL MODELS WERE IMPLEMENTED AND USED**, IN DIFFERENT STAGES OF PROJECT PLANNING, **AS SUPPORTING TOOL TO**

→ **REACH PROJECT GOALS**

- TO DEFINE THE EXTENSION OF THE SITE
- TO DEFINE THE MOST SUITABLE PROJECT CONFIGURATION IN TERMS OF SALINITY DIFFUSION AND HYDRAULIC EFFECTS (PROPER DISCHARGE AND MORPHOLOGICAL CONFIGURATION)

→ **VERIFY POSSIBLE IMPACTS**

- **MONITORING ACTIVITY WILL VERIFY MODELLING PREDICTIONS**
- **EVIDENCES AND LESSONS WILL BE SHARED**

THANK YOU

FOR

YOUR

ATTENTION