LIFE16 NAT/IT/000663 - Life Lagoon Refresh - Coastal lagoon habitat (1150*) and species recovery in Venice Lagoon by increasing the fresh water input and restoring the salt gradient

# Ecological Engineering for transitional water restoration: Life Lagoon Refresh case study

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SER EUROPE
12th SERE CONFERENCE
7th – 10th SEP 2021
online

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Università Ca'Foscari Venezia
IPROS Ingegneria Ambientale

# LIFE LAGOON REFRESH

*Coastal lagoon habitat (1150*) and species recovery by restoring the salt gradient increasing fresh water input*

**Coordinator** ***ISPRA – Italian National Institute for Environmental Protection and Research***

**Project leader** ***Rossella Boscolo Brusà***

## *Budget info*

*Total amount: 3'315'130 Euro*

*% EC Co-funding: 74,13%*

## *Duration*

*Start: 01/09/2017*
*End: 31/08/2022*

## *Location*

*Venice Lagoon*
*ITALY*

## *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***

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**LIFE16 NAT/IT/000663**

# 3 YEARS AFTER SER2018

***WE HAVE ALREDY PRESENTED, AT SERE2018, THE PROJECT STRATEGY AND OBJECTIVES***


***AND WE ARE HERE, THREE YEARS AFTER, TO PRESENT:***

- ***the updated state of realization of conservation actions***
- ***the results of monitoring activities and numerical modelling***
- ***the discussion of this case study in the framework of Ecological Engineering in transitional water restoration.***

# LIFE LAGOON REFRESH
# IN THE ECOLOGICAL ENGINEERING FRAMEWORK

Ecological Engineering (ECOENGINEERING) has been increasingly used to re-create and restore ecosystems degraded by previous human activities.
As reported by Elliot et al. (2016)*, focusing on ecosystem recolonization by the biota and their functioning, there are two type of approach:

| Type A **Ecoengineering**<br>**Engineering the physico-chemical processes** | Type B **Ecoengineering**<br>**Engineering the ecology** |
|---|---|
| Restore the **hydrological processes** and **physico-chemical conditions**;<br>→ Self-improving of ecological structure and functioning | **Biota** are **engineered** directly through e.g. **replanting**. |

In this framework, the LIFE LAGOON REFRESH project foresees the restoration of the **ecotonal environment** in the northern Venice Lagoon, SCI IT3250031, characterized by **marked salt gradient** and large **intertidal areas** vegetated by **reedbeds**, whose presence has been greatly reduced by historical human environmental modifications.

***1 STEP - Engineering the processes (type A)*** → **RECOVERY OF THE SALINITY GRADIENT**

***2 STEP - Engineering the ecology (type B)*** → **REED TRANSPLANTING**

*Elliot et al. (2016)*, Ecoengineering with Ecohydrology: Successes and failures in estuarine restoration. Estuarine, Coastal and Shelf Science Volume 176, 5 July 2016, Pages 12-35*

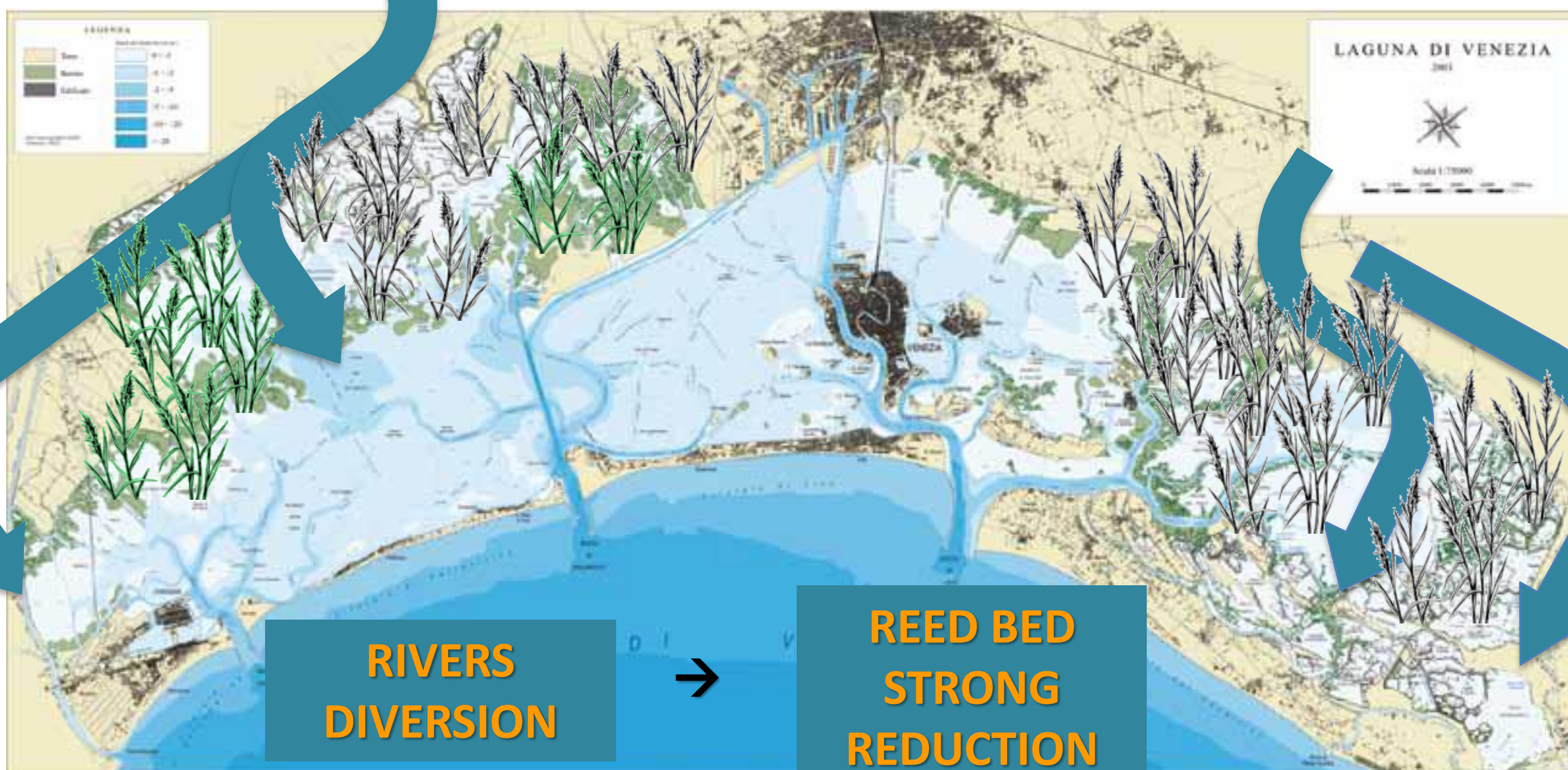
# LIFE LAGOON REFRESH | ENVIRONMENTAL BACKGROUND

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

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**

# LIFE LAGOON REFRESH | AIMS

## Recovery of the salinity gradient

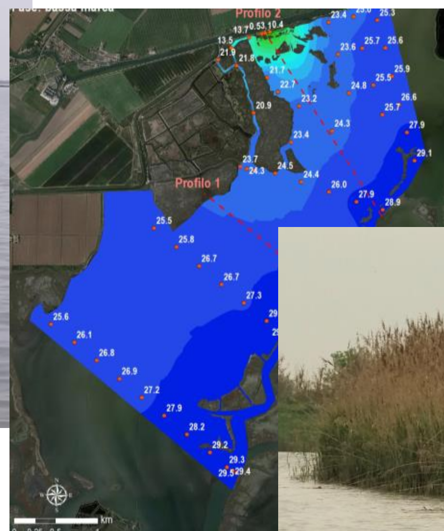
- water salinity: from >30 (annual mean) to <5 (5 ha); <15 (25 ha); <25 (70 ha);
- Reed bed restoration (20 ha): at SCI scale from 30 to 50 ha at the end of the project

## Restoration of reedbed ecosystem services in order to:

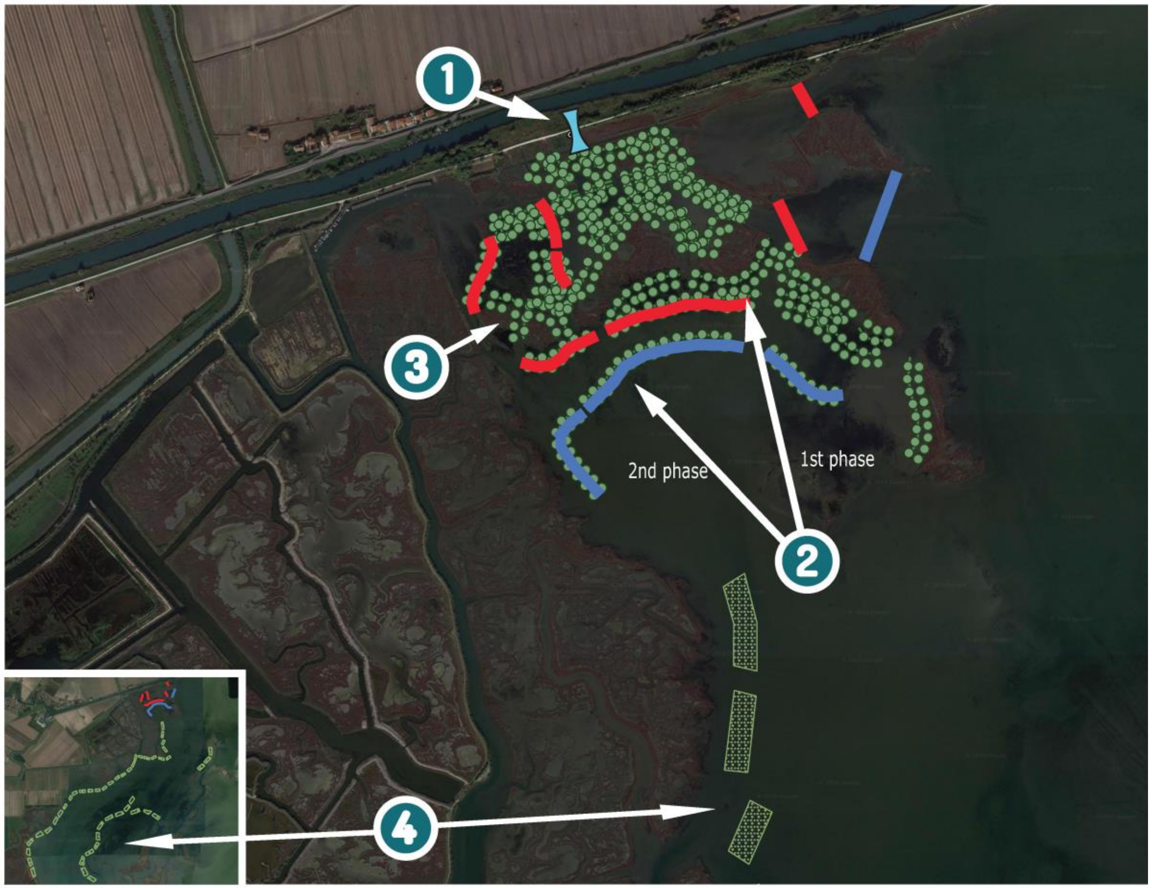
I) improve the Degree of Conservation of habitat 1150* Coastal lagoons;

II) improve the status of bird species of conservation interest;

III) increase the presence of the fish species of conservation (*Pomatoschistus canestrinii*) and commercial interest.




# LIFE LAGOON REFRESH | CONSERVATION ACTIONS




1) diversion of a **freshwater flow** (1.000 l/s) from the Sile river into the lagoon;
2) restoration of the **intertidal morphology** to sustain the reed development;

3) planting of ***Phragmites australis;***
*4)* transplantation of ***Ruppia cirrhosa, Zostera marina*** and ***Zostera noltei****;*

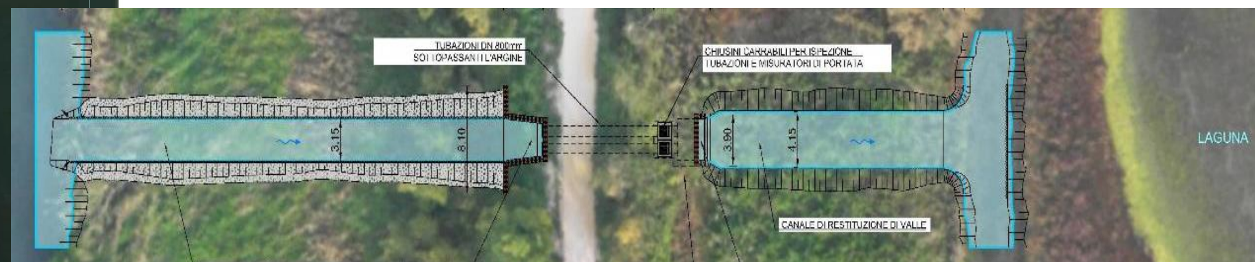
***1 STEP - Engineering the processes (type A)*** → **RECOVERY OF THE SALINITY GRADIENT**

***2 STEP - Engineering the ecology (type B)*** → **REED TRANSPLANTING**

*Elliot et al. (2016)*, Ecoengineering with Ecohydrology: Successes and failures in estuarine restoration. Estuarine, Coastal and Shelf Science Volume 176, 5 July 2016, Pages 12-35*

# LIFE LAGOON REFRESH | CONSERVATION ACTIONS

## 1 HYDRAULIC WORKS


The Hydraulic works consist of two pipelines crossing the right embankment of the Sile river.

**WORKS WERE COMPLETED IN MARCH 2020**

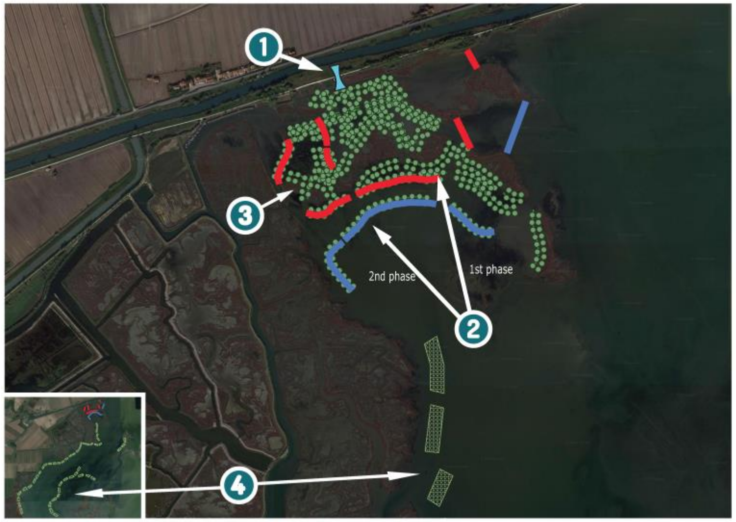
Two sluice gates regulate the discharge from the river to the lagoon. No electromechanical machine – the flow depends on the different water level between river and lagoon.

The diversion of a freshwater flow from the Sile river into the Lagoon was gradually increased starting from 300 l/s (May 2020) to approximately 1000 l/s (February 2021). Real time monitoring of the discharge.

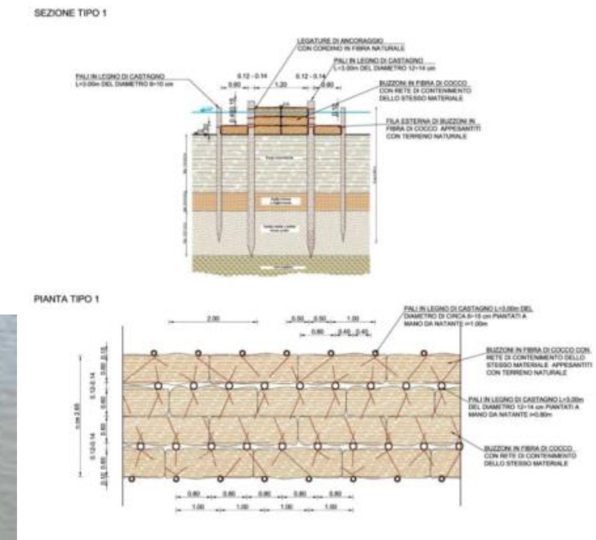
**THE FLOW STARTED IN MAY 2020**

# LIFE LAGOON REFRESH | CONSERVATION ACTIONS

## 2 MORPHOLOGICAL STRUCTURES



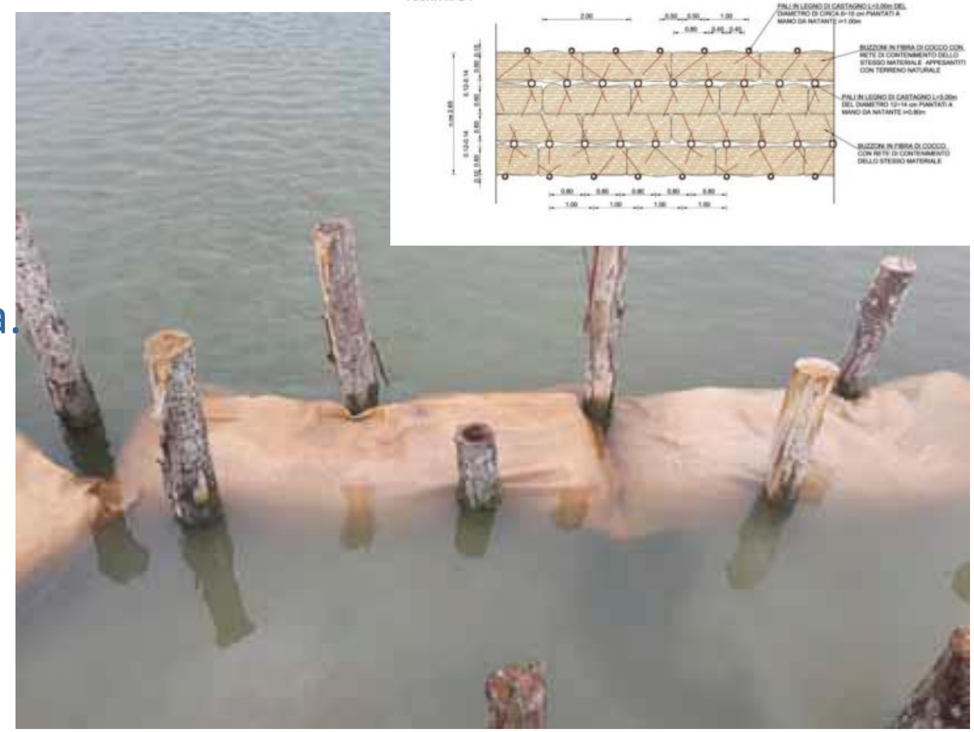

BIODEGRADABLE
GEOTEXTILE
Dimension: 2.40 m
Top: 0.15 m a.s.l.



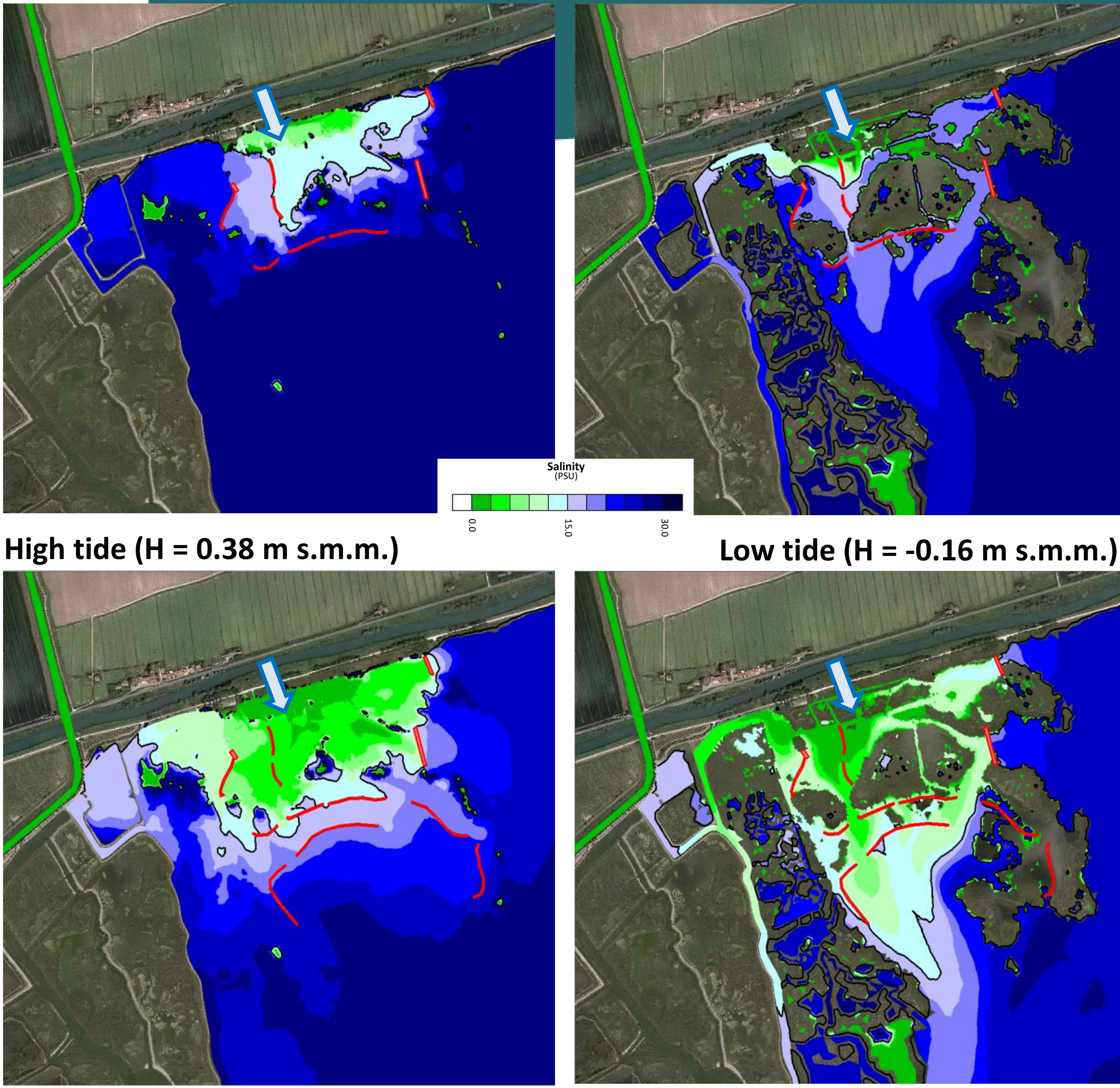

Two lines of modular biodegradables elements, placed on the lagoon shallow area in front of the freshwater intake area.

**THE FIRST LINE WAS COMPLETED IN MARCH 2020**

**THE SECOND LINE WAS COMPLETED IN JUNE 2021**



# NUMERICAL MODELLING AS A TOOL FOR PLANNING




Morpho configuration 1° tranche

Discharge Q = 300 l/s

Morpho configuration 2° tranche

Discharge Q = 1000 l/s

# HOW CAN WE CHECK FOR OBJECTIVE COMPLECTION?

THE CHARACTERIZATION IN TIME AND SPACE OF SALINITY VARIATIONS, PERFORMED BEFORE AND AFTER THE CONSERVATION ACTIONS, IS OBTAINED BY:

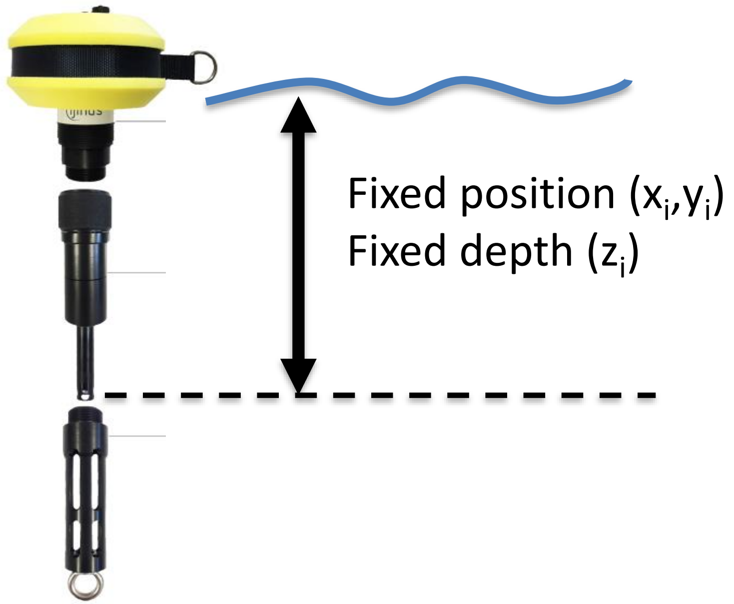
1) MOORED SALINITY PROBES → ACQUISITION, IN A FIXED POSITION, OF CONTINUOUS MEASURED DATA $S(x_i, y_i, z_i, t) = S(t)$

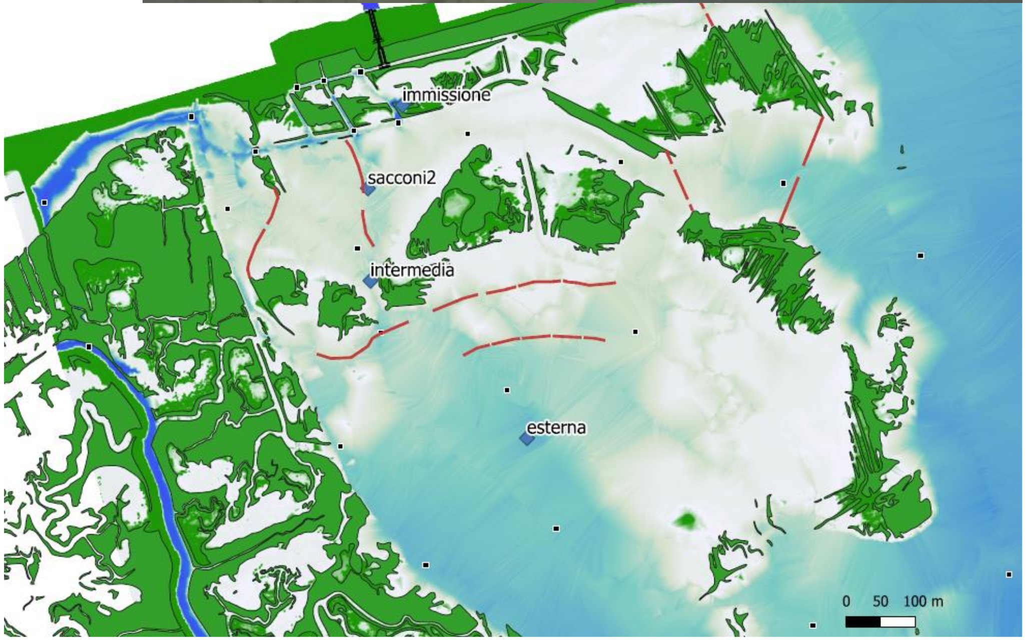
2) FIELD CAMPAIGNS (CTD PROBES) → ACQUISITION OF ISTANTANEUS/ DISTRIBUTED MEASURED DATA $S(x, y, z, t_i) = S\ (x, y, z)$

3) NUMERICAL MODELLING → SIMULATION OF MODELLED DATA WITH VARIATION IN SPACE AND TIME $S(x, y, z, t) = S\ (x, y, z, t)$

# LIFE LAGOON REFRESH | MONITORING OF SALINITY

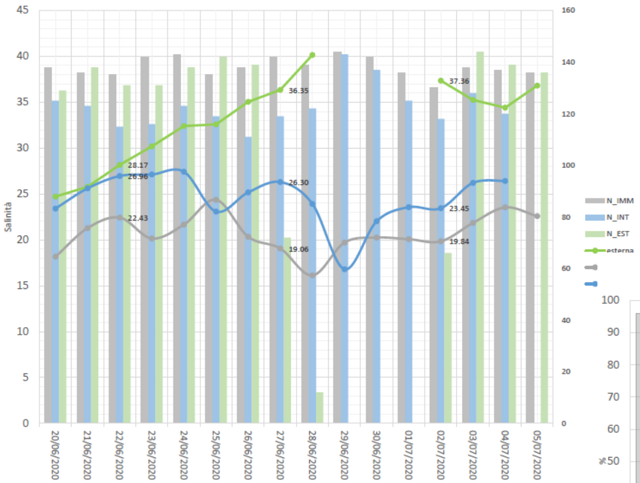
## PROBE IJINUS
## Conductivity + Temperature



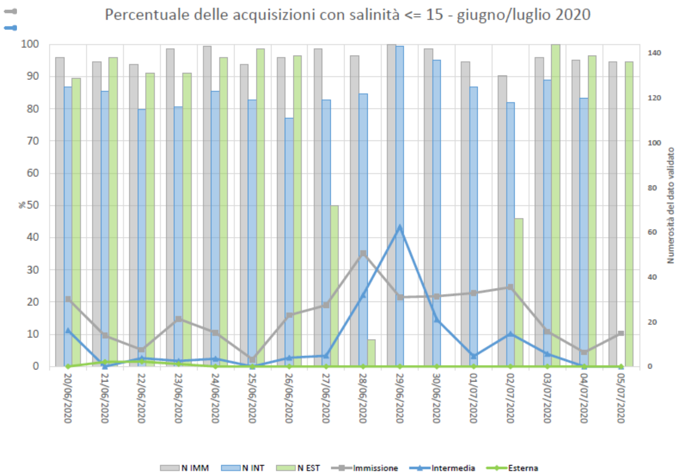




Field set up: september 2018
Frequency of measure: 10 minutes
Frequency of transmission: daily
Frequency of managment: montly

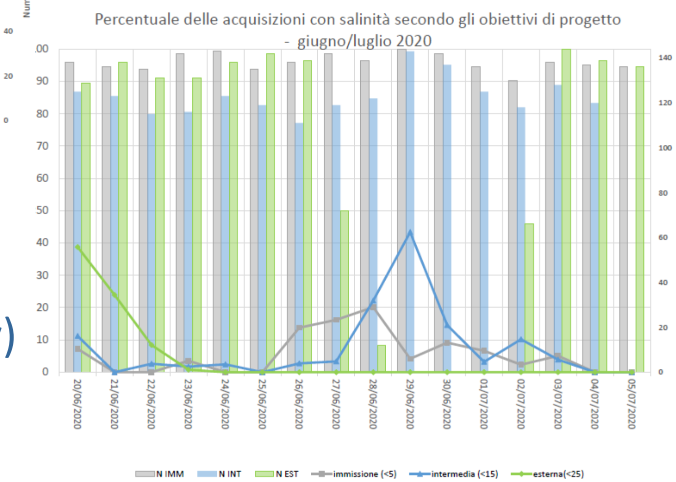
# LIFE LAGOON REFRESH | MONITORING OF SALINITY




daily mean value and number of valid acquisition




evaluation of salinity < 15 (threshold for reedbed suitability)




evaluation of salinity < specific thresholds (5 – 15- 25)

# CTD CAMPAIGNS

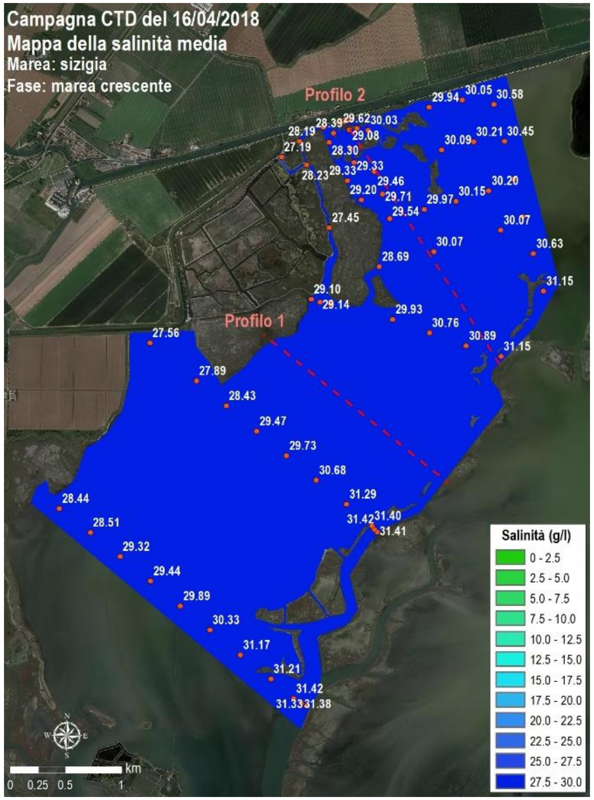
COMBINED STRATEGY

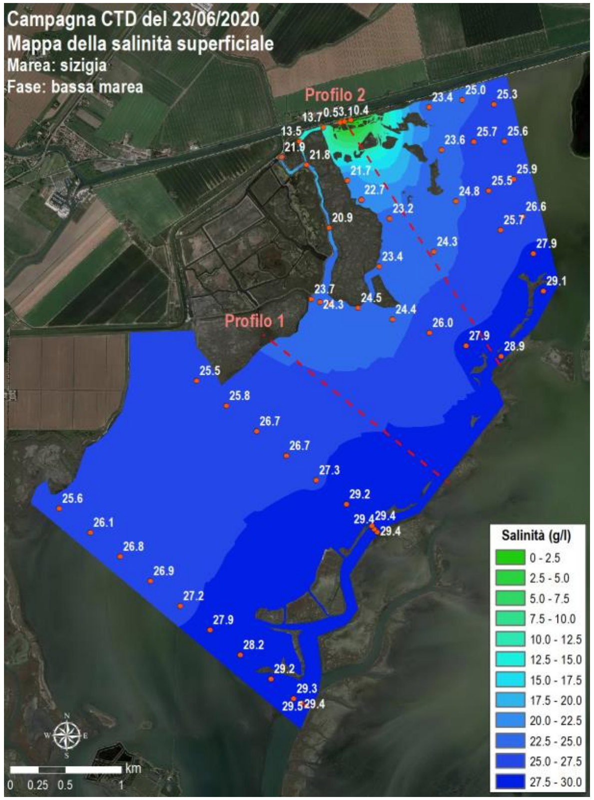
✓ LOCAL SCALE: measures on detailed grid, evalutation of local effects in the intervention area (about 1.3 km2 - 25 vertical profiles)- IPROS

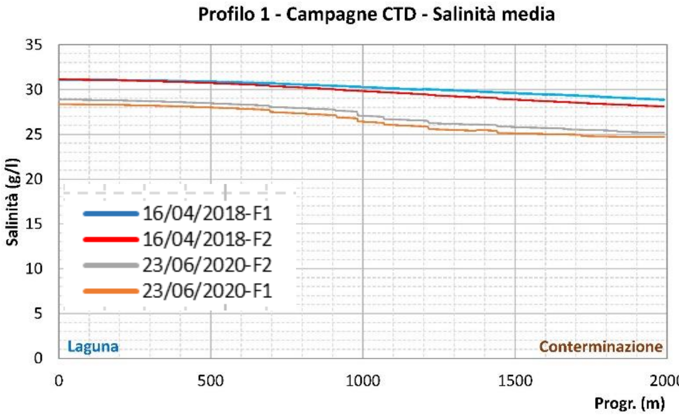
✓ LARGE SCALE: measures along transects, evalution of gradients - ISPRA

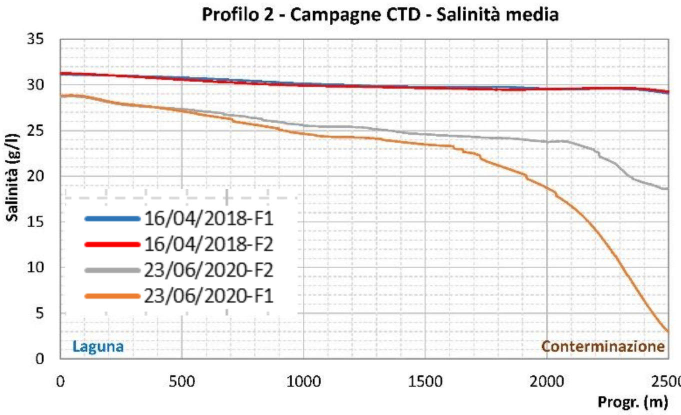

- VERTICAL PROFILES
  - TWO TIDAL PHASES (F1, F2) to evaluate min and max diffusion as a function of tidal level
  - TWO FIELD CAMPAIGNS per year, to evaluate different tidal conditions (spring-neap tide)

# LIFE LAGOON REFRESH | MONITORING - CTD



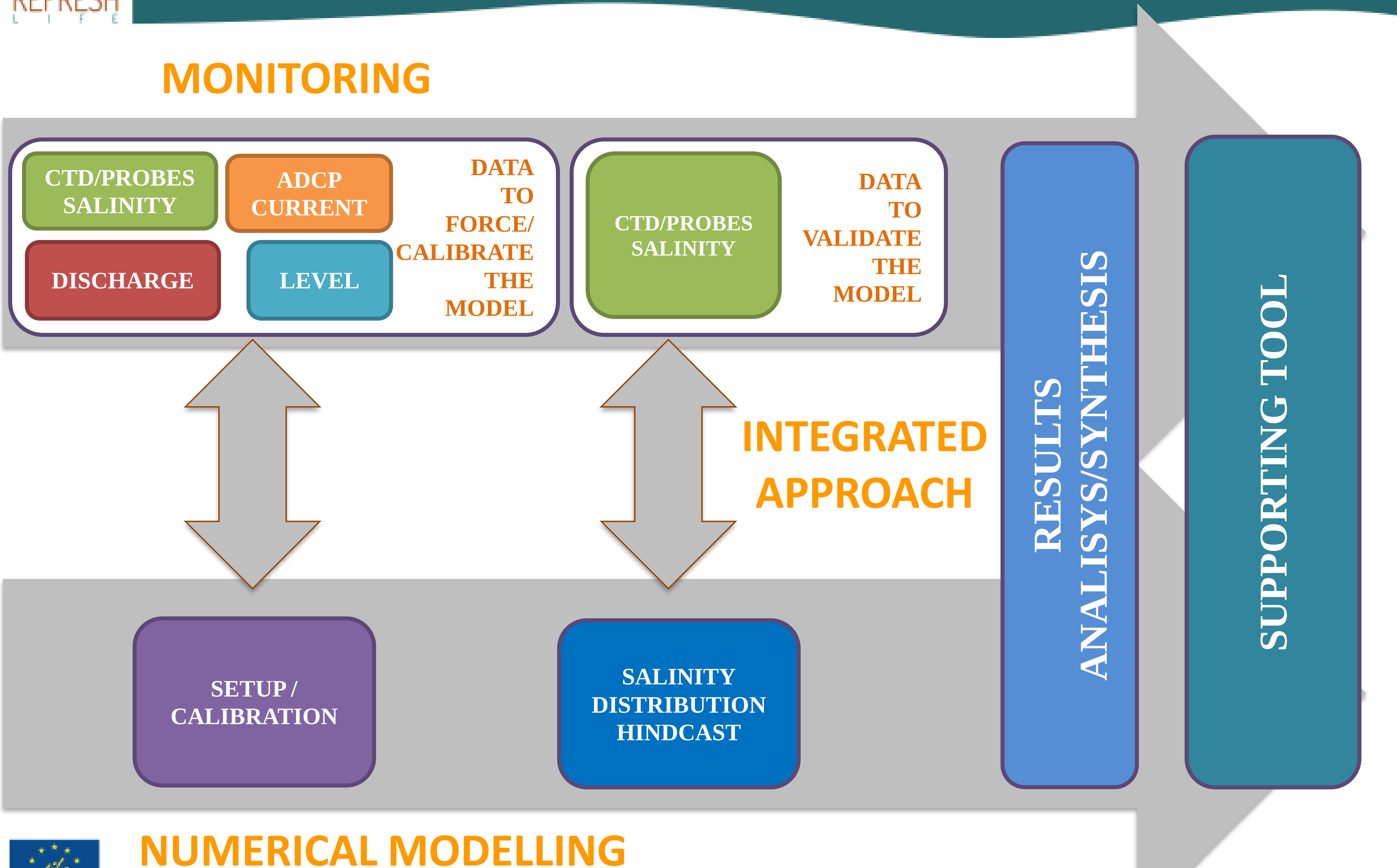




ANTE OPERAM
(16/04/2018)

INFLOW of 300 l/s
(23/06/2020)

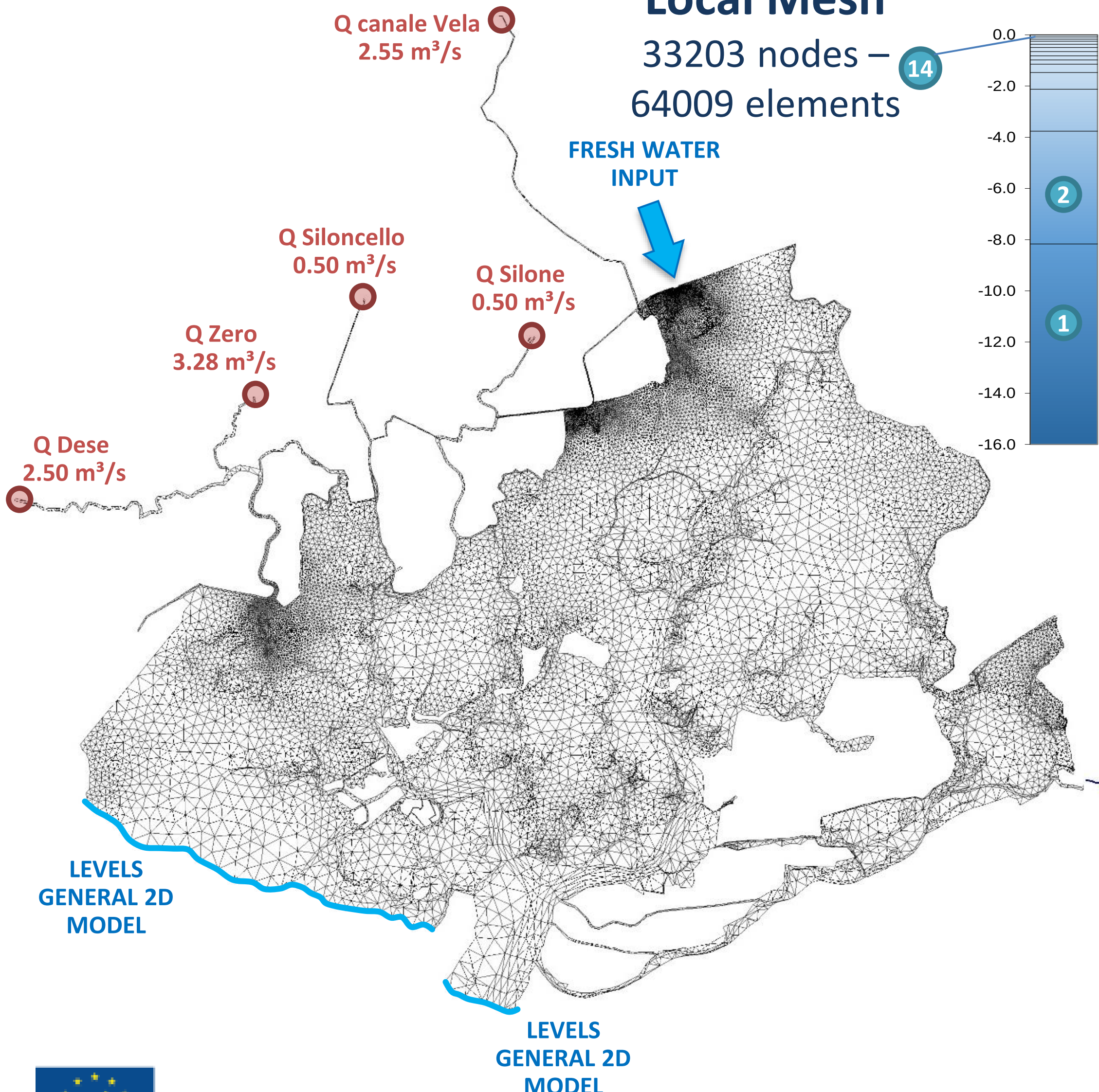
# LIFE LAGOON REFRESH | MONITORING & MODELLING



# LIFE LAGOON REFRESH | 3D MODELLING

## Local Mesh

33203 nodes – 64009 elements

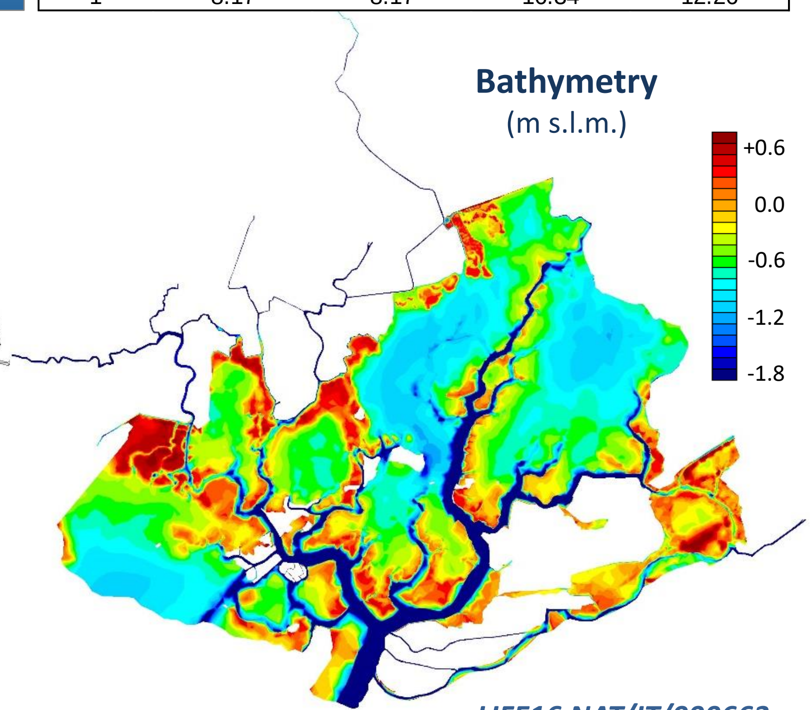



## Vertical layers

| LAYER N | THICK. (m) | FROM (m) | TO (m) | MEAN DEPTH (m) |
|---|---|---|---|---|
| 14 | 0.08 | 0.00 | 0.08 | 0.04 |
| 13 | 0.08 | 0.08 | 0.16 | 0.12 |
| 12 | 0.08 | 0.16 | 0.25 | 0.20 |
| 11 | 0.12 | 0.25 | 0.37 | 0.31 |
| 10 | 0.12 | 0.37 | 0.49 | 0.43 |
| 9 | 0.16 | 0.49 | 0.65 | 0.57 |
| 8 | 0.16 | 0.65 | 0.82 | 0.74 |
| 7 | 0.16 | 0.82 | 0.98 | 0.90 |
| 6 | 0.16 | 0.98 | 1.14 | 1.06 |
| 5 | 0.33 | 1.14 | 1.47 | 1.31 |
| 4 | 0.65 | 1.47 | 2.12 | 1.80 |
| 3 | 1.63 | 2.12 | 3.76 | 2.94 |
| 2 | 4.41 | 3.76 | 8.17 | 5.96 |
| 1 | 8.17 | 8.17 | 16.34 | 12.26 |

## Bathymetry

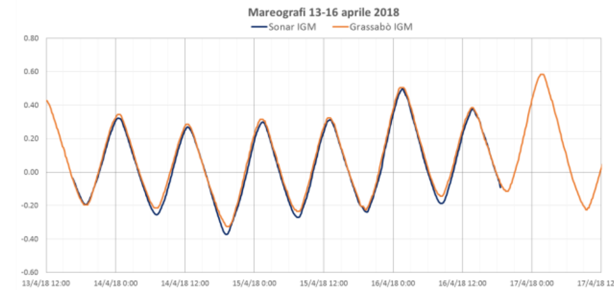
(m s.l.m.)



# NUMERICAL MODELS NEED REAL DATA TO BE CALIBRATED

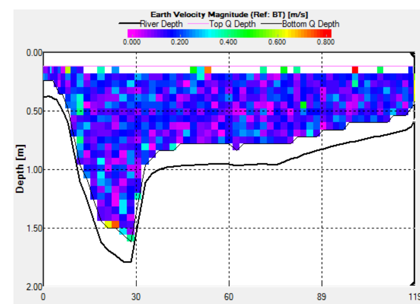
**WATER LEVEL**

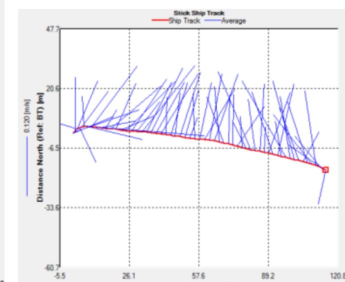
TIDE LEVEL STATIONS




**CURRENT SPEED**

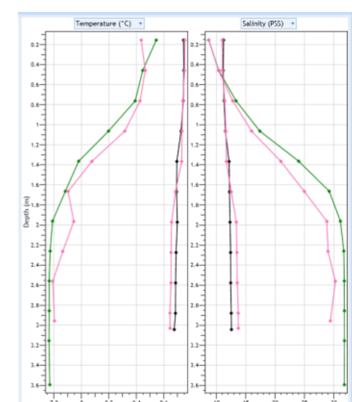
ADCP FIELD CAMPAIGNS




**SALINITY**

CTD FIELD CAMPAIGNS -MOORED STATIONS



# LIFE LAGOON REFRESH | MONITORING & MODELLING

| | | MONITORING | | NUMERICAL MODELLING |
|---|---|---|---|---|
| | month | moored probes | CTD campaign | Model |
| before fresh water input | apr-18 | X | X | |
| | … | x | | |
| | oct-18 | X | X | |
| | … | x | | |
| | … | x | | |
| | apr-20 | x | | |
| Inflow | may-20 | x | | |
| 300 l/s | jun-20 | X | X | X |
| | oct-20 | x | | |
| | nov-20 | x | | |
| 500 l/s | dic-20 | x | | |
| | jan-21 | x | | |
| | until 12/02/2021 | x | | |
| 1000 l/s | since 12/02/2021 | X | X | X |

DATA TO VALIDATE THE MODEL

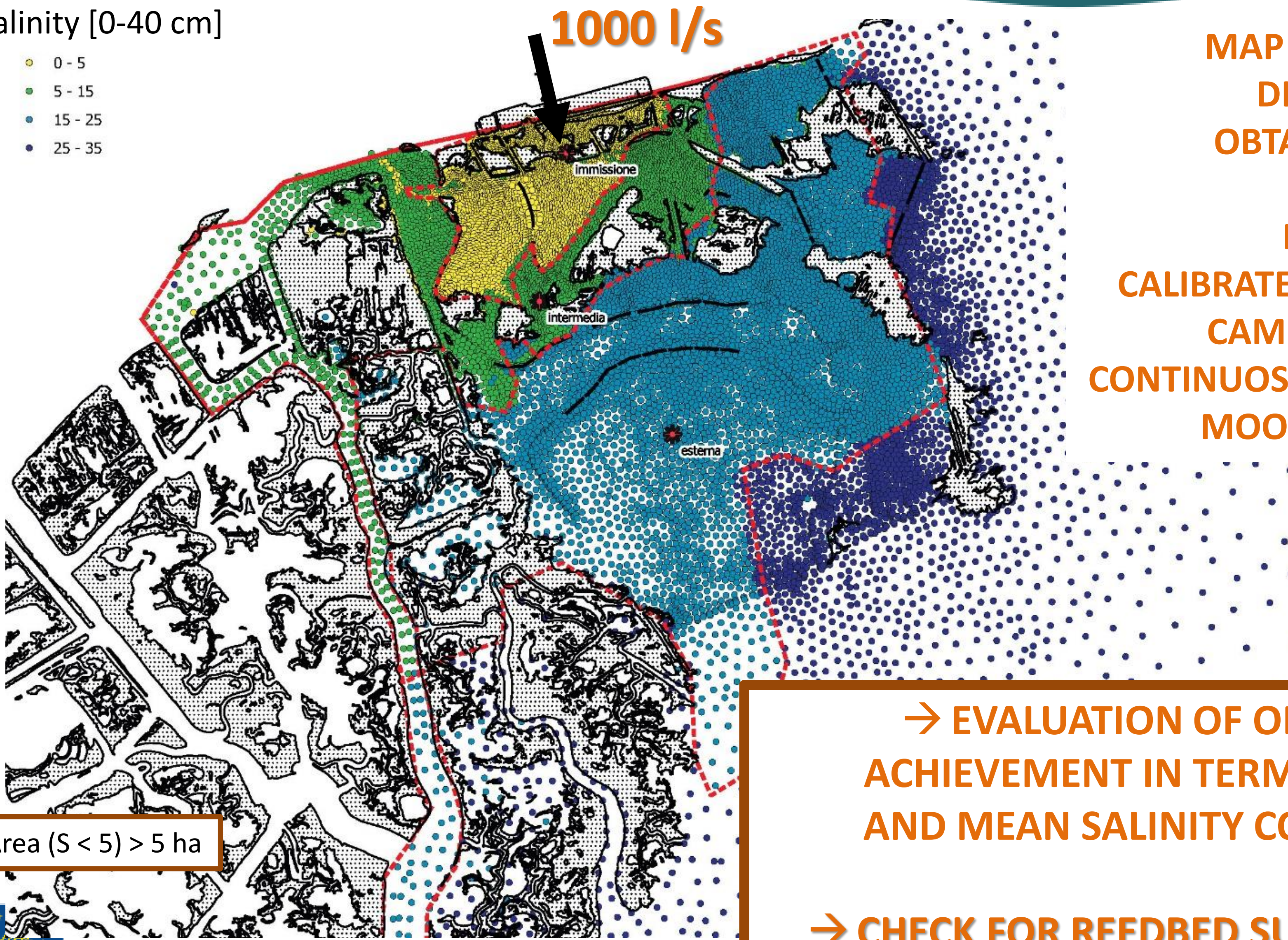
SALINITY DISTRIBUTION HINDCAST

## INTEGRATED APPROACH

# LIFE LAGOON REFRESH | MODEL RESULTS

Salinity [0-40 cm]

- 0 - 5
- 5 - 15
- 15 - 25
- 25 - 35



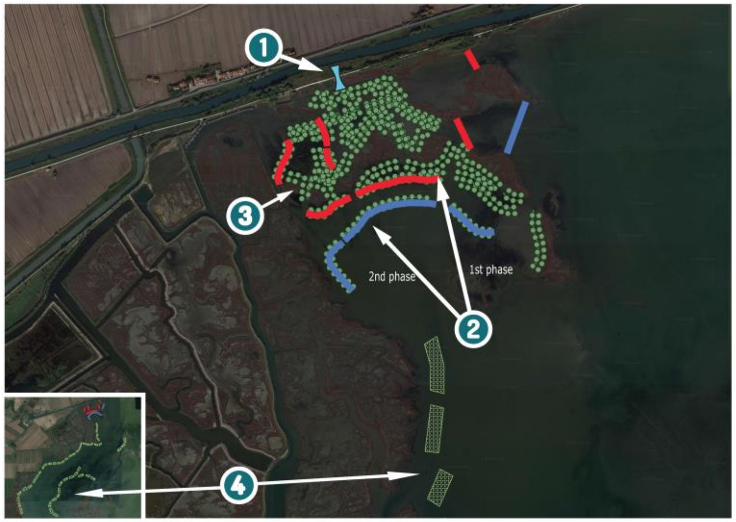

Area (S < 5) > 5 ha

MAP OF SALINITY DISTRIBUTION OBTAINED FROM NUMERICAL MODELLING, CALIBRATED WITH CTD CAMPAIGNS AND CONTINUOS DATA FROM MOORED PROBES

→ EVALUATION OF OBJECTIVES ACHIEVEMENT IN TERM OF AREA AND MEAN SALINITY CONDITION

→ CHECK FOR REEDBED SUITABILITY

# LIFE LAGOON REFRESH | CONSERVATION ACTIONS




## NOW THAT WE HAVE CHECKED FOR REEDBED SUITABILITY…

## IT IS TIME TO TRANSPLANT

## 3 REEDBED TRANSPLANTATION

Planting of clumps (ca. 1000 of 10-15 cm in diameter) and rhizomes of *P. australis* over a total linear extension of approx. 10000 m.

**ON-GOING IN 2021**

LAGOON REFRESH LIFE

# Thank you!

lifelagoonrefresh

@LagoonRefresh

Life Lagoon Refresh

www.researchgate.net/project/Life-LAGOON-REFRESH

**www.lifelagoonrefresh.eu**

**lagoonrefresh@isprambiente.it**