ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

12th International SedNet Conference
SEDIMENT CHALLENGES AND OPPORTUNITIES DUE TO CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT
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Sustainable sediment management in coastal infrastructures through the innovative ejectors plant technology

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SEDIMENT MANAGEMENT IN MARINE INFRASTRUCTURES

The problem: Sediment dynamic in harbours and ports usually creates **sedimentation** and/or **erosion** concerns, producing navigability limitations or beach erosion.

The available solution: **Dredging**, which is a well-known and effective technology, but accompanied by high environmental impacts.

The environmental issues related to dredging:

- sediment **dispersion** and **resuspension**,
- **turbidity**,
- damaging of marine **fauna and flora**,
- emissions (**GHGs and pollutants**) into air and water,
- **underwater noise**.

Moreover, dredging has also **relevant technical and economic issues**:

- negative impact on **water bathing**,
- variable **cost**,
- complicated routes for **permit/authorization**,
- during operations, the dredge **hinders navigation**,
- the dredge **cannot operate** if the weather and sea conditions do not allow it,
- the dredge is **not always available**.

Bray Harbour (Ireland)

Mechanical dredge in operation

NATURAL SEDIMENTATION VS. DREDGING

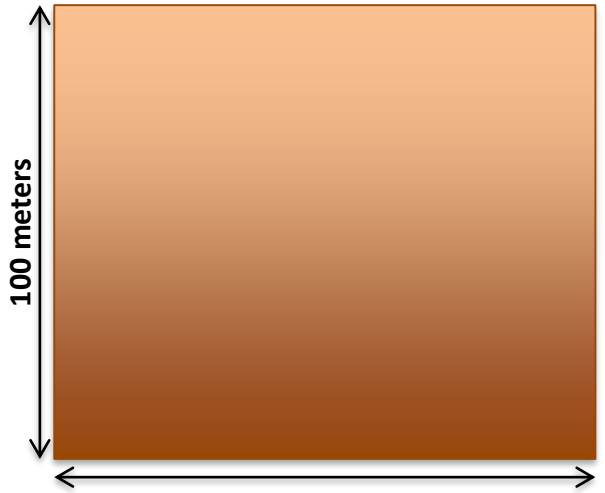
Let's consider a square water body area of 100 m per 100 m affected by sediment accumulation that produces 1 meter of water depth loss per year. It means 100 m x 100 m x 1 m = 10,000 cubic meters of sediment to be managed in one year.

Dredging operation is usually short term. Consider 10 days operation, 8 working hours per day: it means that the dredge will remove the sediment accumulated in one year with a rate of 1,000 m^3/day, or 125 m^3/hour.

But if the natural sediment accumulation rate is considered, given that the natural phenomenon develops for 356 days in a year, a different rhythm, in average terms, can be found:

- about 27 m^3 per day (vs. 1,000 m^3 of the dredge),

- about 1.2 m^3 per hour (vs. 125 m^3/h of the dredge).



Example

Area 100m x 100m = 10,000 m^2

Water depth decreasing = 1 m/year

Sediment volume = 10,000 m^3/year

→125 trucks

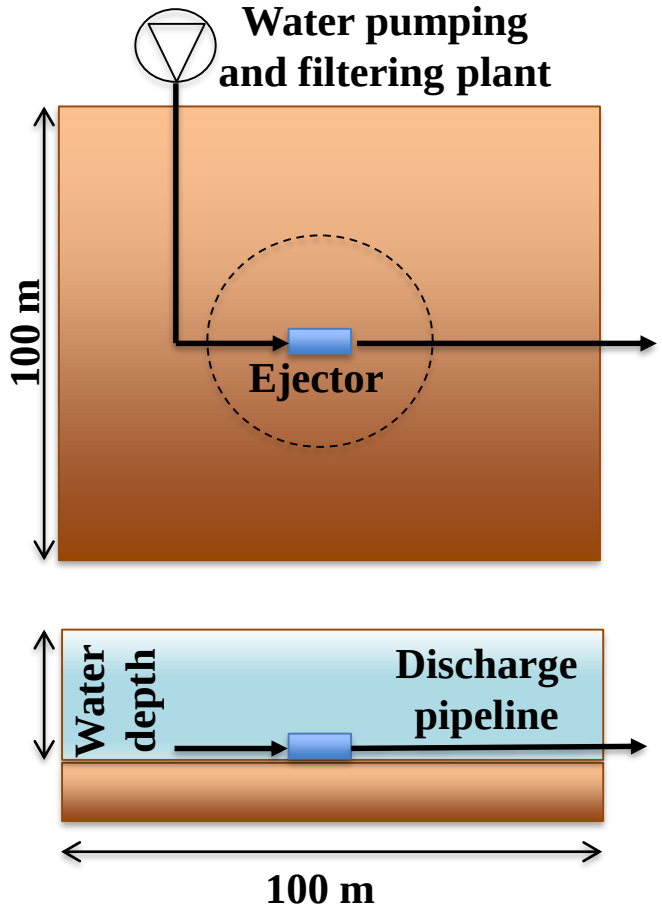
Sediment flowrate = 10,000/8,600 =

= 1.2 m^3/hour

→6 drums

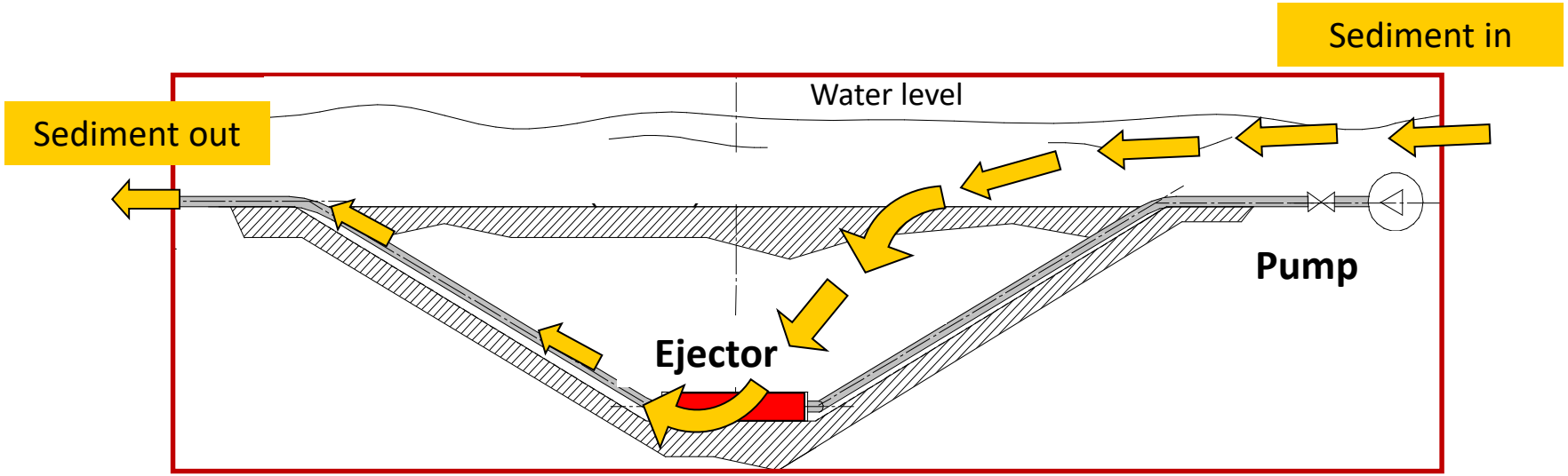
200 lt

THE EJECTORS PLANT TECHNOLOGY: A NEW APPROACH TO ADDRESS SEDIMENTATION



The "*ejector plant*" is mainly realized through the assembling of a pumping-filtering station that feeds with pressurized water one or more ejectors through a system of pipelines. Each ejector has one water feeding line and one discharge line that transports a water-sediment slurry.

The original idea was to design a system able to continuously remove the sediment that tends to settle, a system that works with the rhythm of nature.



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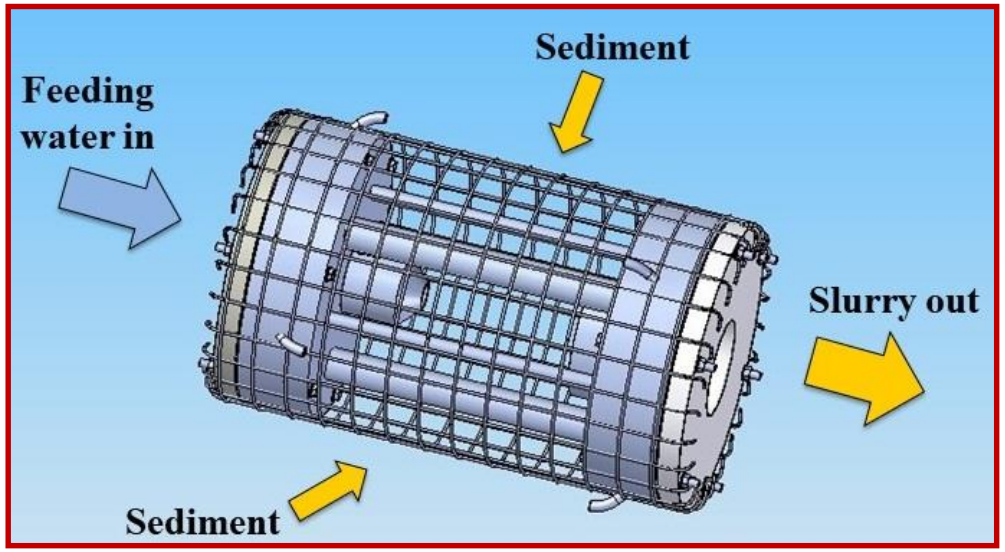
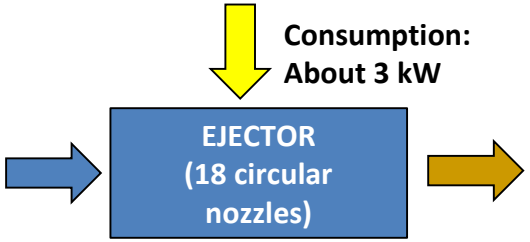
THE EJECTORS PLANT TECHNOLOGY: WORKING PRINCIPLE

The working principle of the ejector is based on the <u>combined effect of two different nozzles' jets</u>: the radial nozzles create a suspended mixture of water and sediment, while the central nozzle sucks up through the Venturi effect the water-sediment mixture and collect it in a discharge pipeline.





<u>Primary flowrate</u>: 43,5 m^3/h, of which 27 m^3/h on the central nozzle.

<u>Discharge flowrate</u>: 34 m^3/h (water + sediment)

Below the ejector performance for a <u>60 meters long discharge pipeline</u>:
The ejector sucks about 7 m^3/h of water-sediment mixture.
The mean value of the mixture ratio is 0.10 kg of sediment per kg of mixture.
Sediment (sand bulk density): 2.000 kg/m^3.
Sediment flowrate: about **<u>2 m^3/h</u>**.

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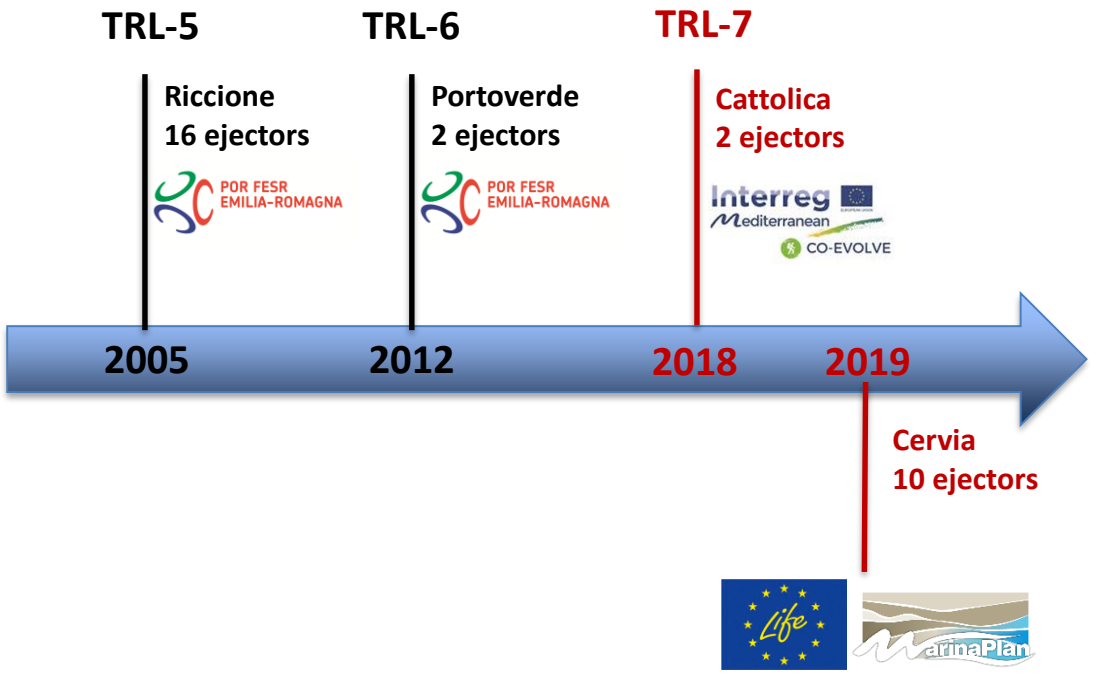
THE EJECTORS PLANT TECHNOLOGY: THE DEVELOPMENT

The technology has been already tested and validated in Italy in three installations in the North Adriatic Sea. The last (fourth) application in 2019 is related to the LIFE MARINAPLAN PLUS project, which financed the realization and extensive monitoring of a 10-ejectors demo plant in the channel inlet of Marina di Cervia (Italy). The demo plant operated continuously from Jun 2019 to Sep 2020.



Expected results to be achieved

Bring the ejectors plant technology over TRL-7 through the realization of an industrial-scale demo plant
Monitoring for at least 15 consecutive months demo plant operation
Environmental impact assessment
Develop a business model
Evaluate the impact and sinergies with Maritime Spatial Planning

TREVI
COMUNE DI CERVIA
ALMA MATER STUDIORUM A.D. 1088
ICOMIA International Council of Marine Industry Associations

https://www.lifemarinaplanplus.eu → virtual tour of the demo plant available

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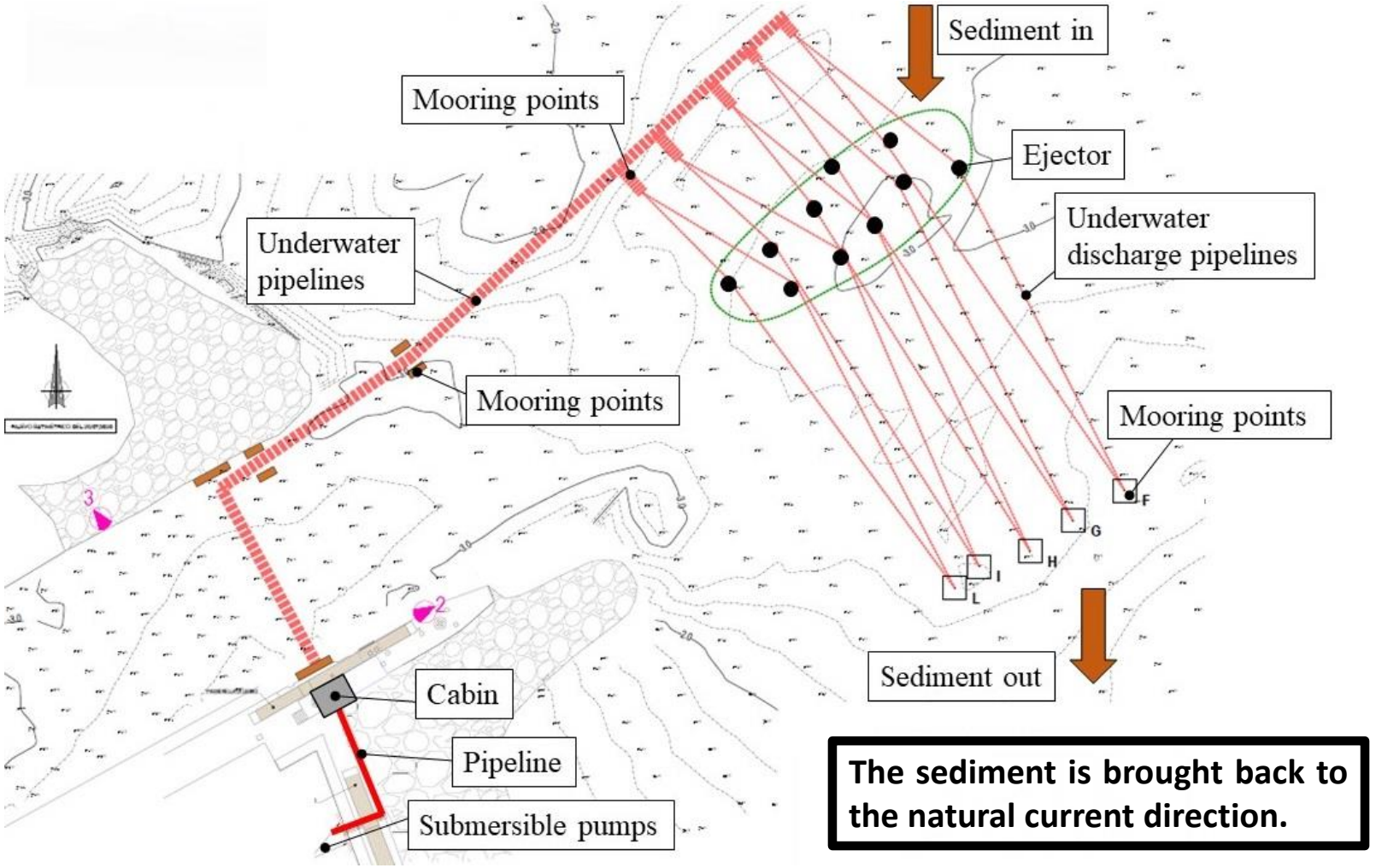
THE EJECTORS PLANT TECHNOLOGY: DEMO PLANT IN MARINA DI CERVIA

Marina di Cervia
280 berth
channel – 21 m width

The cabin



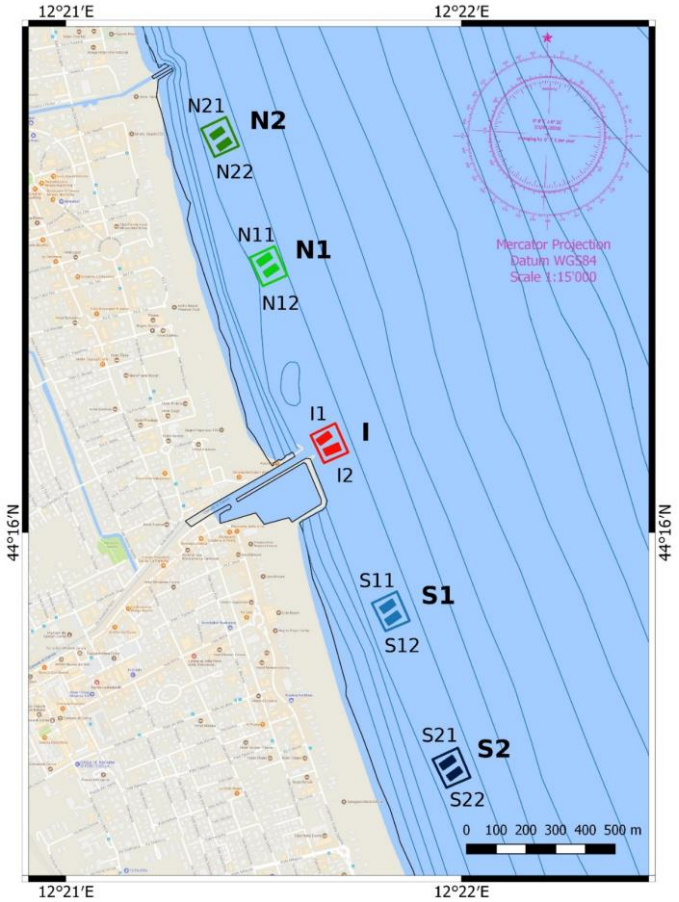
The sediment is brought back to the natural current direction.

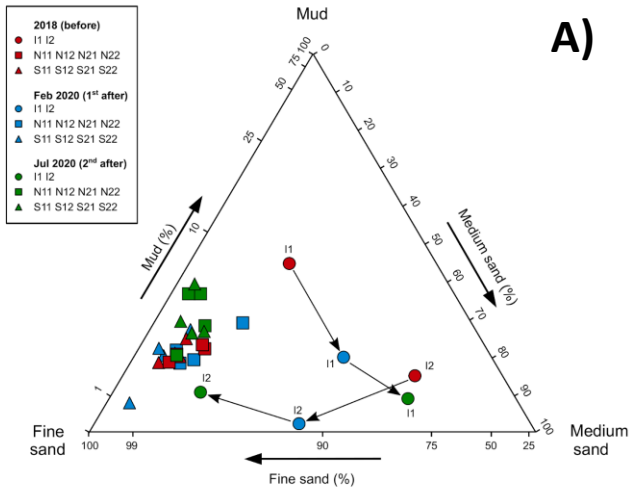
DEMO PLANT VIDEO

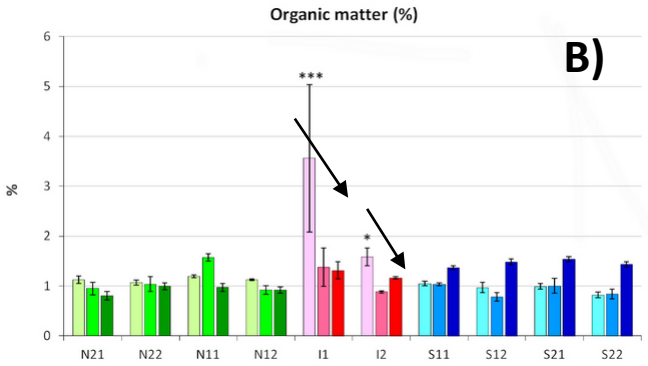
→ Link to the video https://www.youtube.com/watch?v=BtAm1xOK1F0

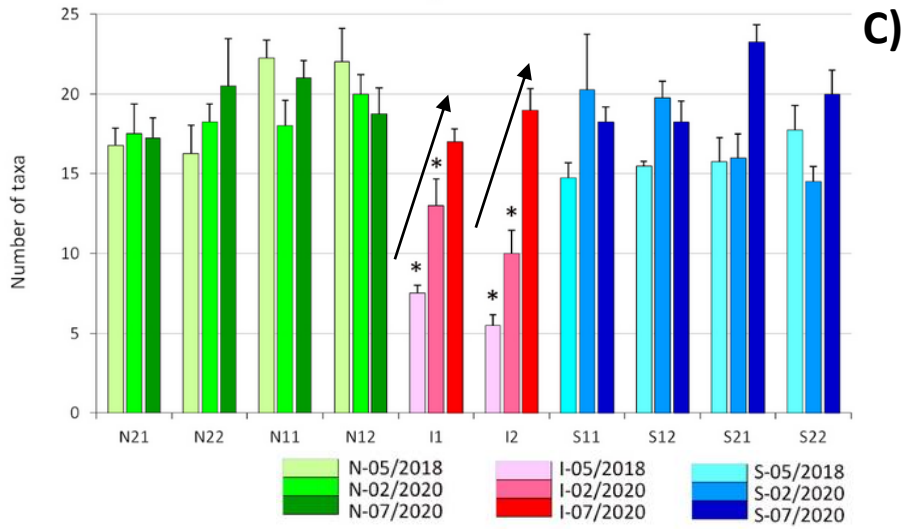
ENVIRONMENTAL IMPACT ASSESSMENT

The impacts on sediment, benthic and fish assemblages were evaluated with and without the demo plant in operation. The final results show a reduction of the percentage of muddy fraction (Figure A) and of organic matter content (Figure B) in the impact (I) location after demo plant operation. Conversely, species richness of marine macro-invertebrates (Figure C) significantly increased after the demo plant was put into operation. Fish assemblages were not influenced by demo plant operation.









References:
https://www.iadc-dredging.com/article/sustainable-coastal-seabed-plan/

Final results (including 3rd sample campaign) will be published in the second half of 2021.

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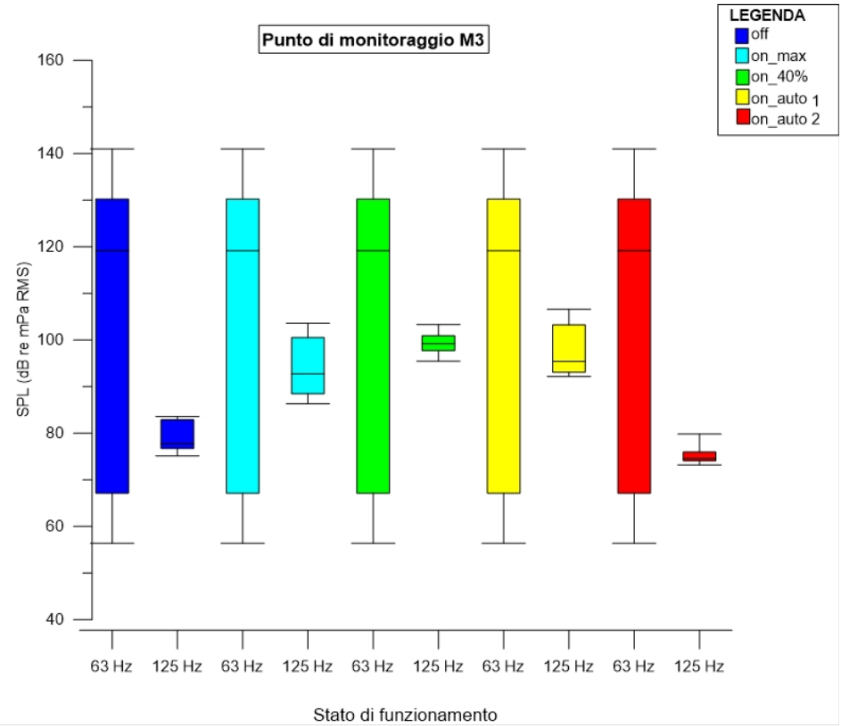
ENVIRONMENTAL IMPACT ASSESSMENT

The impact on underwater noise has been assessed for both ejectors (points M3 and M4 in the map) and submersible pumps (points B1, B2 and B5) impacted areas. The measurements have been realized with the demo plant in operation at different submersible pumps rpm (controlled by inverters) and with the demo plant not in operation.

The results show almost no variation in the noise levels for the center frequency band at 63 Hz, while a variation in the frequency band centered at 125 Hz is visible for both sampling points. Nevertheless, the statistic analysis shows no clear relation between the measured noise level at 125 Hz and the ejectors plant operation. Complete set of results will be published in the second half of 2021.



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ENVIRONMENTAL IMPACT ASSESSMENT

The impact on greenhouse gases (GHGs) and pollutants emission has been evaluated through life cycle assessment (LCA) method. The comparison has been made with traditional maintenance dredging operation, including also the option of sediment resuspension through dredger's propellers operation.

The results show a relevant reduction of both GHGs and pollutants emissions. Therefore, ejectors plant technology can contribute to reduce the impacts on the air, especially if renewable energy is used to power the water pumps.

Emission (kg/year)	Dredging	Ejectors plant	Ejectors plant powered by renewables
CO_2	59096 (100%)	82%	5%
CO	138 (100%)	10%	<1%
NOx	1468 (100%)	2%	<1%
SOx	374 (100%)	3%	<1%
VOC	52 (100%)	23%	2%

Furthermore, it is relevant to underline how the ejectors plant generates a decentralized and continuous impact, while maintenance dredging produces impacts that are local and in short period, thus with higher intensity than ejectors plant technology.

The whole LCA results will be published in the second half of 2021.

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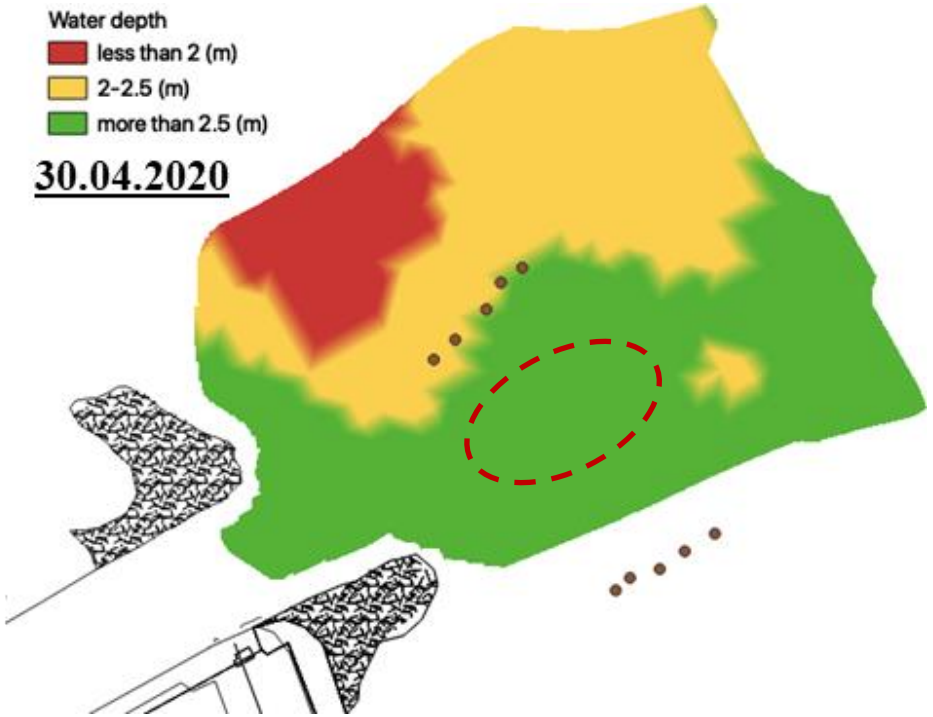
EFFECTIVENESS ASSESSMENT

The demo plant in Cervia operated continuously for 15 months by keeping the minimum water depth always over the target of 2.5 meters at the harbour entrance.

Results about demo plant efficiency will be published in the second half of 2021.



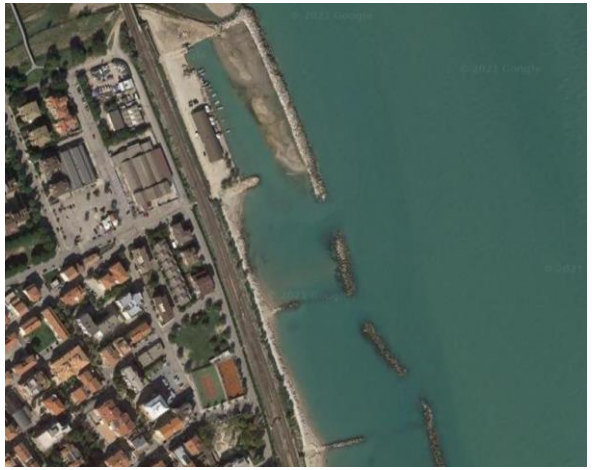
References:
https://www.mdpi.com/2077-1312/9/2/197/review_report

NEXT STEPS

LIFE MARINAPLAN PLUS project partners are now looking for commercial and technical partners to promote market up-take of the technology in different applications.

Harbour's inlet
(Houmt Souk harbour, Tunisia)

Port's docks
(Tripoli port, Lebanon)



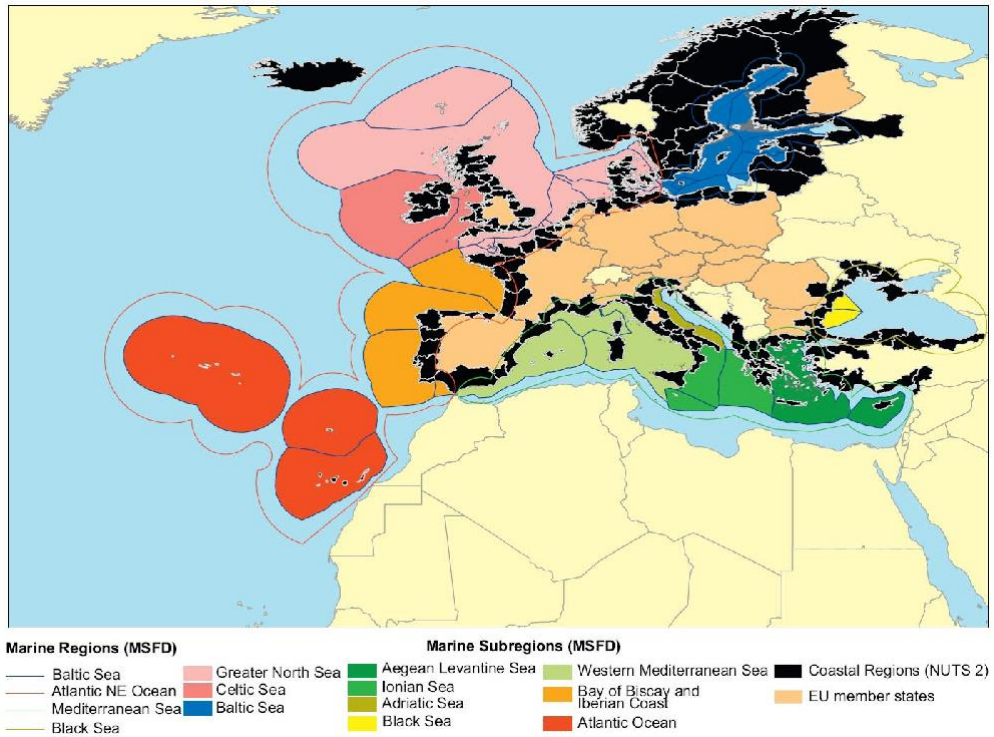
Combination with anti-erosion infrastructures
(Pedaso, Italy)

Ordinary maintenance of banks and waterways at the same time

Dam and reservoir maintenance

Furthermore, some improvements will be tested in the next installations regarding anti-fouling systems (to prevent filters and pipelines clogging) and underwater sensors and communication protocols to remotely and continuously check the status of ejectors and of discharge pipeline (i.e. flowrate and sediment content).

CONCLUSIONS



The ejectors plant technology is a key element for effective and sustainable planning of sediment management within maritime space management plans, especially in harbour and port areas, because:

- **ejectors plant adoption helps to mitigate the pressure produced by anthropogenic activities on the marine ecosystem, since it generates substantially zero impacts on biodiversity, bottom integrity and underwater noise indicators, unlike the dredge;**

- **when coupled with renewable energy sources, the ejectors plant impact may result as negligible and can have relevant equivalent CO_2 and pollutant emissions reduction if compared with traditional dredging.**

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