B3.3 Seabed maintenance management plan

Reliable and innovative technology for the realization of a sustainable MARINe And coastal seabed management PLAN

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1. Introduction

The scope of the report is to described how the seabed maintenance management plan (SMMP) for a port can be designed and applied. The report shows the results arising from the experience of demo plant design, installation and operation in the Marina of Cervia, and it includes a general schematization of how it can be replied, including relevant guidelines about stakeholders engagement.

2. Navigability and maintenance dredging

The viability of the economy of the European Union is clearly dependent upon the continued development and maintenance of the nation's waterways, ports, and harbors for navigation. In fact, more than 90% of global trade is carried by waterborne transport, constituting by far the most important means of transport of goods. Therefore, global trade is critically dependent on adequate ports and waterways navigation status (**navigability**), since a limited water depth reduces vessel and boat draught, which is strongly related with load capacity, thus impacting on goods and people traffic volumes and related costs. Preservation of a good port navigability is a challenging issue, since port access and waterways are often hampered, as the vast majority of 10.000s of ports worldwide suffer from **sedimentation**. Traditionally, the sediment that causes the problem of siltation is excavated, removed and relocated: this operation is defined as "**maintenance dredging**". Millions of cubic meters of such sediment are dredged annually from harbour approaches, fairways and basins to safeguard obstructed navigation. Dredged volumes are expected to increase due to continued economic growth and increases in vessel and boat draught. Maintenance dredging is thus necessary at both large commercial and small craft harbours.

Maintenance dredging has great technological, economic and environmental disadvantages. First of all, **dredging is not effective in keeping navigability over the time**. This objective may be reached through a higher frequency of dredging operations, but would result in higher costs and complex authorization/permit procedures. Maintenance dredging also has **considerable environmental impacts**, since dredging operations can: i) destroy or greatly modify underwater habitat, ii) disturb contaminants already present in the water bed, thus increasing the Suspended Solid Concentration (SSC) in the water column with negative effects for the ecosystem, iii) impact locally on greenhouse gas (GHG), pollutants and noise emissions, iv) generate a waste to be disposed, i.e. the dredged material. There is an increasing expectation for infrastructure projects to add value beyond the economic dimension since sustainability issues are of growing importance. In fact, ports and governmental organisations are demanding more sustainable products and services, and the main leverage to achieve this objective is through more **restrictive legislation**. As a result, maintenance dredging operations are often becoming **difficult to plan**, too expensive and sometimes not allowed by regulators.

Figure 1 summarizes the structure of a maintenance dredging plan. In the preliminary phase the area interested by maintenance dredging is assessed in terms of status quo of water depth and chemical-physical characterization of sediment to be dredged. Sediment characterization is a crucial point since it highly influences the available disposal route for the dredged material. Depending on physical composition (sand, silt and clay percentage) and pollutants/contaminants content, the dredged sediment can be used for beach nourishment, disposed in the marine environment or treated and then landfilled. Therefore, characterization of sediment is fundamental also for the evaluation of maintenance dredging costs. The definition of the objectives of the maintenance dredging includes water depth needs in specific areas of the port (i.e. entrance, docks, internal waterways, towing basins), considering also tides range influence. The definition of water depth targets is affected by several parameters (see Figure 2) is mainly based on maximum vessel drafts – loaded cargo, visiting yachts, tall ships, hosting sailing regattas (some racing boats have very deep drafts). In particular, loaded cargo drafts rocketed in the last years (see Figure 3) and fostered the demand for high depth navigability. Nevertheless, reaching the desired water depth may have some limitations in terms of economic and environmental sustainability, which should be preliminary assessed. As a consequence, maintenance dredging plan can be hampered by both economic and environmental concerns. Actions needed to complete the maintenance dredging are complying with permits and procedures, the execution of dredging (which can be impeded or delayed on the basis of weather conditions), and management of dredged material. Based on specific experience and local permit/authorization procedures, an advanced maintenance, also called “overdredging”, can be planned. Also financing is a relevant step, since most of the maintenance dredging activities are carried out by public companies or local authorities, which usually have financial and bureaucratic limitations of spending. Maintenance dredging includes the dredger cost, the cost for dredged sediment management and the cost for the authorization (i.e. chemical-physical characterization of the sediment). Finally, the monitoring of water depth over the time as well as the environmental impacts monitoring during maintenance dredging are fundamental as tools for decision makers and new maintenance dredging planning.

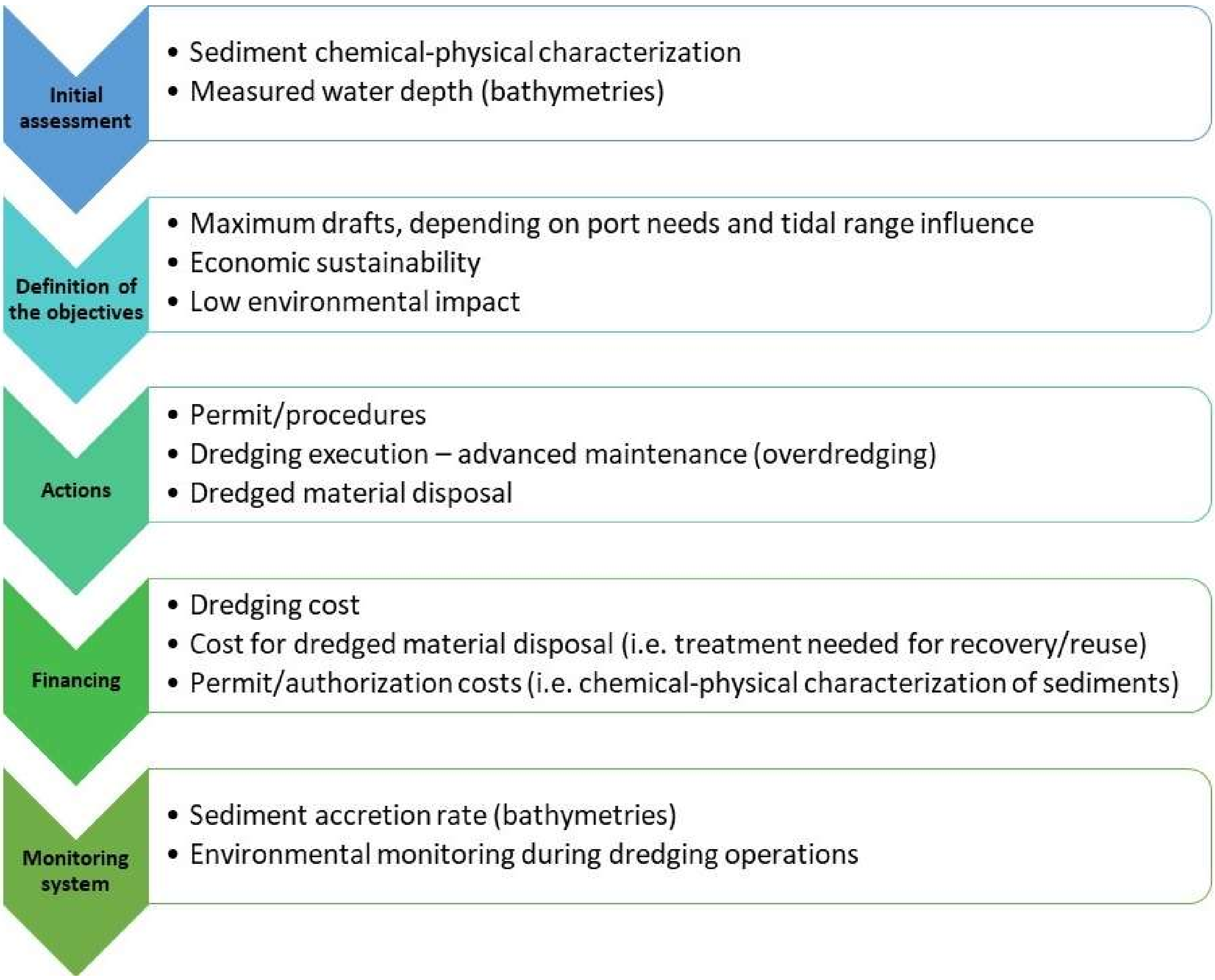

Figure 1. Schematization of a maintenance dredging plan.

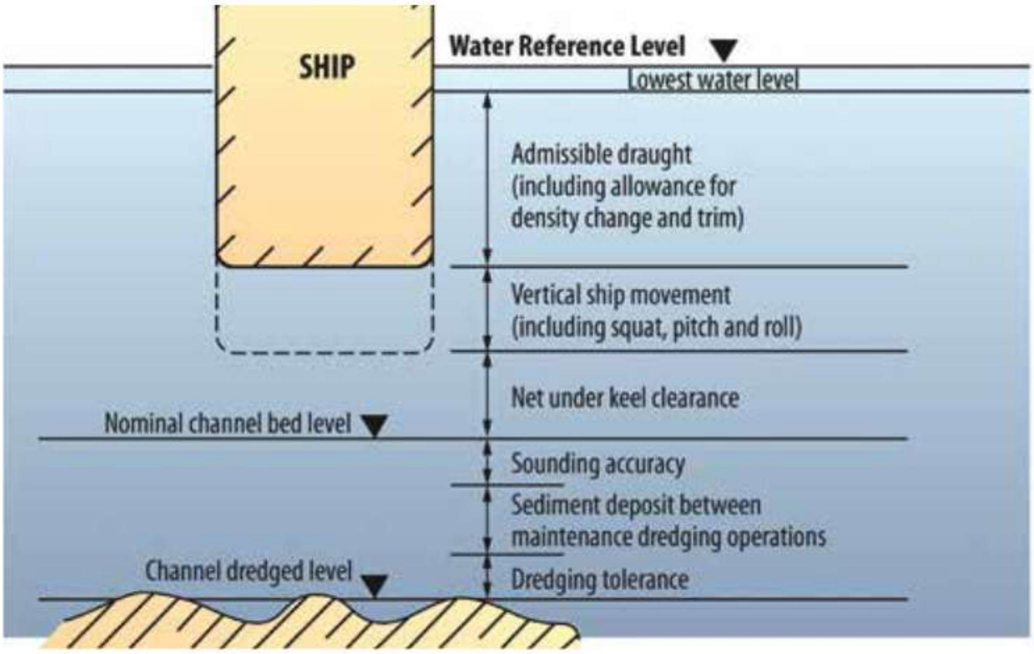

Figure 2. Components of water depth design.

Figure 3. Evolution of loaded cargo draft.

The presence of many stakeholders and often long and complicated permit procedures usually require at least months for maintenance dredging to be planned. Indeed, **long-term maintenance dredging planning** should be strategic for port management, but it is not a common practice. Only few references can be found in literature (like in Australia[1] or UK[2]). This is probably a consequence of technical and administrative complexity of maintenance dredging planning.

[1] Guidelines for Long-term Maintenance Dredging Management Plans, State of Queensland (Department of Transport and Main Roads), 2018.
[2]Sustainable sedimentation management in the medina estuary: a forward look at maintenance dredging needs, practices and management, Cowes Harbour Commission, 2018.

3. The seabed maintenance management plan

The **"ejectors 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 ejectors plant has been developed and designed to **continuously shape the water bed and to keep it at a certain depth over the time** with the following targets:

i) no-moving mechanical-electrical parts in the ejector,
ii) minimize the environmental impact,
iii) no water turbidity,
iv) being not an obstacle for navigation while in operation,
v) being easy to integrate within the water body architecture and landscape.

The ejector works with the sediment that naturally comes to a certain area, and so it does not remove the sediment from that area. The result is that from both technical and normative points of view **the operation of the ejectors plant is not a dredging**. The ejectors plant completely **disrupts the approach to sediment management** since it has the unique feature of **combining navigability and sustainability**, as proved by the 15 months of demo plant operation in Cervia. The adoption of the ejectors plant technology allows to move from a maintenance dredging planning to a seabed maintenance management planning. Ince installed, sedimentation in critical areas for navigability and port approaches is addressed by the ejectors plant operation, meaning that the **sediment management** is **continuous** and **automatic**, thus being more similar to an industrial approach than dredging, and it is mainly affected by a proper **operation and maintenance plan of the ejectors plant**.

Figure 4 shows a schematization of the structure of the seabed maintenance management plan. Each section of the plan is also related with LIFE MARINAPLAN PLUS project actions.

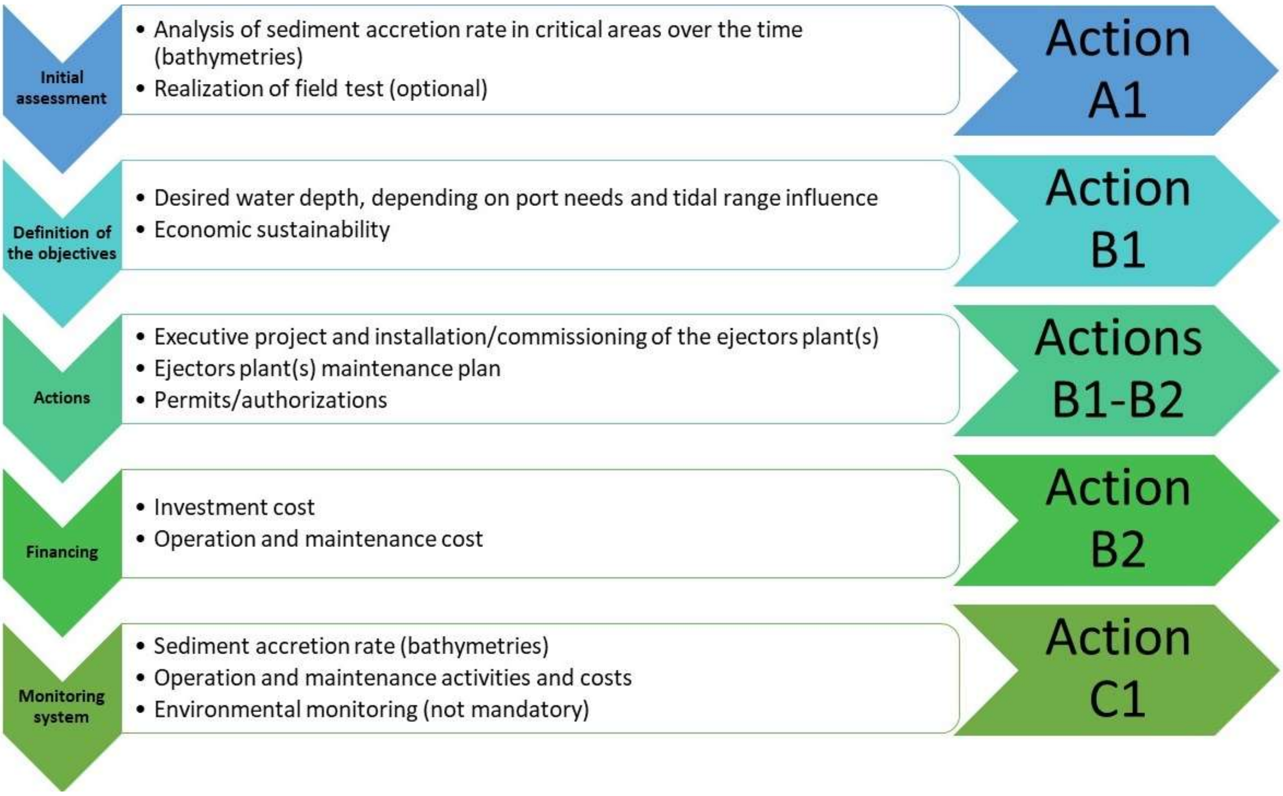

Figure 4. Structure of the seabed maintenance management plan and relation with LIFE MARINAPLAN PLUS project Actions.

3.1 Initial assessment

In a first phase the **current status of the port is assessed**, foreseeing the collection of relevant data about **sediment characteristics and dynamic**, **past sediment management activities** (including investments and operation costs in maintenance dredging), analysis of **site morphology** and **infrastructures barriers**. The first phase should include also an analysis of the **predominant pressure and impacts**, including human activities, on the environmental status of marine waters, focusing on dredging activities in particular. Furthermore, the current level of **economic and industrial activities performance related to the port operation** should be evaluated to estimate economic benefits arising from a better navigation status.

The development of **preliminary tests** to evaluate how ejectors can work on local conditions, with an approach similar to the one realized in Cervia in action A1, could be an interesting step to quantify with higher accuracy relevant parameters and key performance indicators related to ejectors operation, thus ensuring a more effective evaluation of ejectors plant potential impacts on seabed maintenance.

3.2 Definition of objectives

The second phase concerns the **establishment of targets** to guide progress towards the ejectors plant design and application in the port. The targets are defined on the basis of key performance indicators monitored in actions C1 and regarding the ejectors plant performances and impacts. Since the demo plant of Cervia shown a near-zero environmental impact, most of monitoring actions implemented in the LIFE MARINAPLAN PLUS project will be not necessary or mandatory, like on seabed integrity or underwater noise. The main target is related to the design water depth to be kept constant over the time. The other targets are economic ones, i.e. ejectors plant cost, operation and maintenance costs. The option of feeding with renewable power the ejectors plant should be evaluated to further minimize the environmental impact and reduce operation costs. Table 1 shows the list of key performance indicators as assessed in Action C1 of the LIFE MARINAPLAN PLUS project. The list includes also **extraordinary dredging cost**. In fact, it is fundamental to highlight that ejectors plant technology can minimize, and in some circumstances completely avoid the use of dredging equipment, but it is useful to plan the use of dredging equipment if necessary to address extraordinary seabed maintenance needs.

Table 1. Key performance indicators to set ejectors plant targets.

Area of impact	Key performance indicator	Unit of measure
Navigability	Water depth	Meter
	Area interested by sedimentation issues	Square meter
Economic	Installation cost	€ per installed ejector
	Operation cost	€/year per installed ejector
	Maintenance cost	€/year per installed ejector
	Extraordinary dredging	€/year
Environmental	Energy consumption	kWh/year
	CO_2 equivalent emissions	Tons of equivalent CO_2/year

3.3 Actions

The actions needed to put in place the seabed maintenance management plan are related to the:

i) design of the ejectors plant(s);
ii) installation and commissioning of the ejectors plant(s);
iii) operation and maintenance of the ejectors plant(s).

All these phases should be accompanied by the **early engagement of all the relevant stakeholders** involved by the ejectors plant(s) realization, operation and maintenance. Figure 5 shows a map of the stakeholders. In particular, it is strongly recommended to contact since the feasibility study (i.e. initial assessment) all the local authorities which may have some **permit, authorization or technical opinion** to release. It is important to underline how the operation of the ejectors plant does not need a dredging permit. Nevertheless, the installation of the ejectors plant, the use of public areas (if any), the realization of civil works (if needed) and other activities may need to be authorized by local authorities.

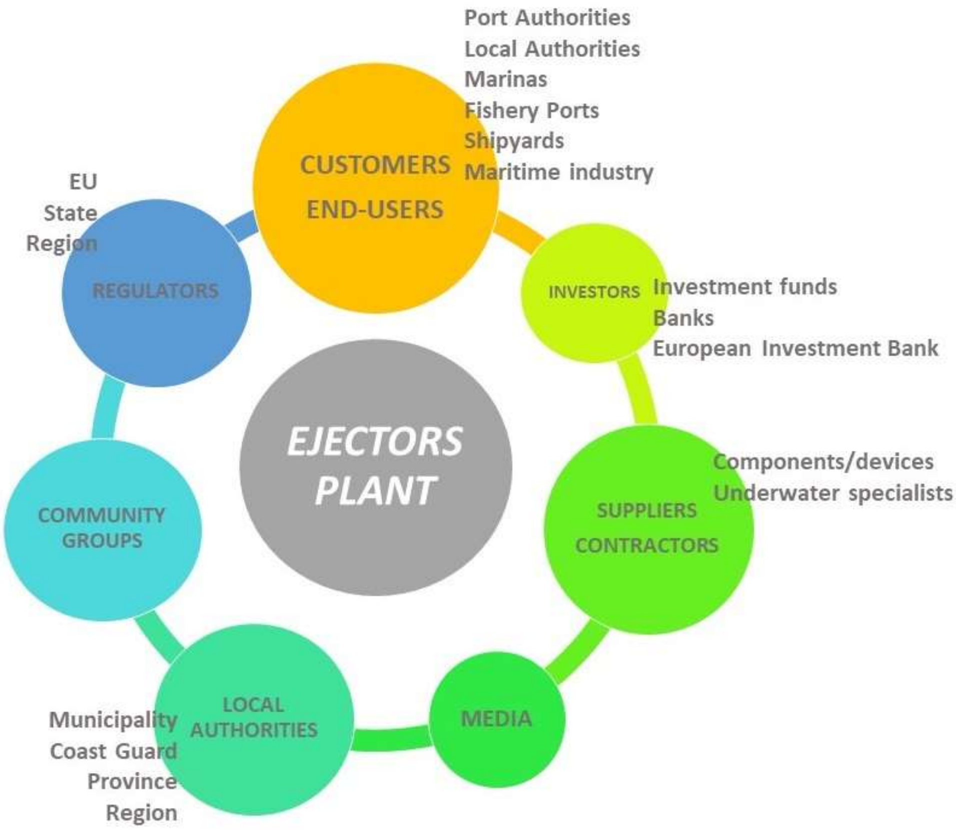

Figure 5. Stakeholder map.

3.4 Financing

The definition of ejectors plant targets includes also economic. Therefore, it is important that, based on the business model applied, the customer and/or Trevi has the **financial capacity** to manage year by year the ejectors plant and to implement the seabed maintenance management plan.

3.5 Monitoring system

Monitoring action of seabed maintenance management plan is a fundamental step to produce data and give tools to support decision making about the tuning of the on-going plan. The first parameter to monitor is related to **ejectors plant effectiveness**, i.e. water depth variation in the area of influence. The other relevant parameters connected to the ejectors plant operation that need to be monitored are **energy consumptions** and **maintenance activities**. Navigability guaranteed all over the year can produce relevant **economic (and social) impacts**, like cargo/vessel/boat traffic increasing, but they are complex and expensive to monitor. Such an evaluation can be more easily performed in large scale port, like city Ports, while it is more complicated to be organized in Marinas and small ports in general. City Ports and Ports Authorities may also have the opportunity to **monetize environmental benefits** of ejectors plant(s) operation in comparison with maintenance dredging, so they could be encouraged to evaluate also the economic and social impacts which follow a better ecological status of the marine environment (i.e. higher seabed integrity, no GHGs and pollutants local emission, no underwater noise, no dredged material disposal). In this case, the environmental key performance indicators included in Table 2 could be assessed.

Table 2. Environmental key performance indicators (see Deliverable C1.9).

Environmental key performance indicator	**Unit of measure**
Pollutant emissions	kg (or ton) eq per year
Underwater noise	dB Re 1 μPa
Dredged material to be disposed	ton (or m^3) per year
Sensitivities to environmental stress of five ecological group of macrobenthic species	AMBI and M-AMBI indices
Macrobenthic and fish assemblages	Beyond BACI
Sea bottom sediment grain size and organic matter	Beyond BACI

4. Seabed maintenance management plan: Cervia demo plant results

4.1 Initial assessment

Through the analysis of the last 10 years' bathymetries performed by Cervia Municipality it was possible to **verify how the natural sand transport is interrupted** by the docks of Cervia harbour channel. See, for example, the two bathymetries that are shown in Figure 6: on the left side are the bathymetries plotted after sediment handling through propellers (May 2009), while on the right side the bathymetries seven months later (December 2009). The red lines in Figure 6 indicate the – 2.00 m of water depth, which is considered as the critical value for safety navigation at the harbour inlet of Cervia. Figure 6 clearly shows how the sand moves from North to South by turning around the northern dock (a vortex can be seen) and then entering the harbour inlet. A similar trend can be observed in the bathymetries from 2010 to 2018.

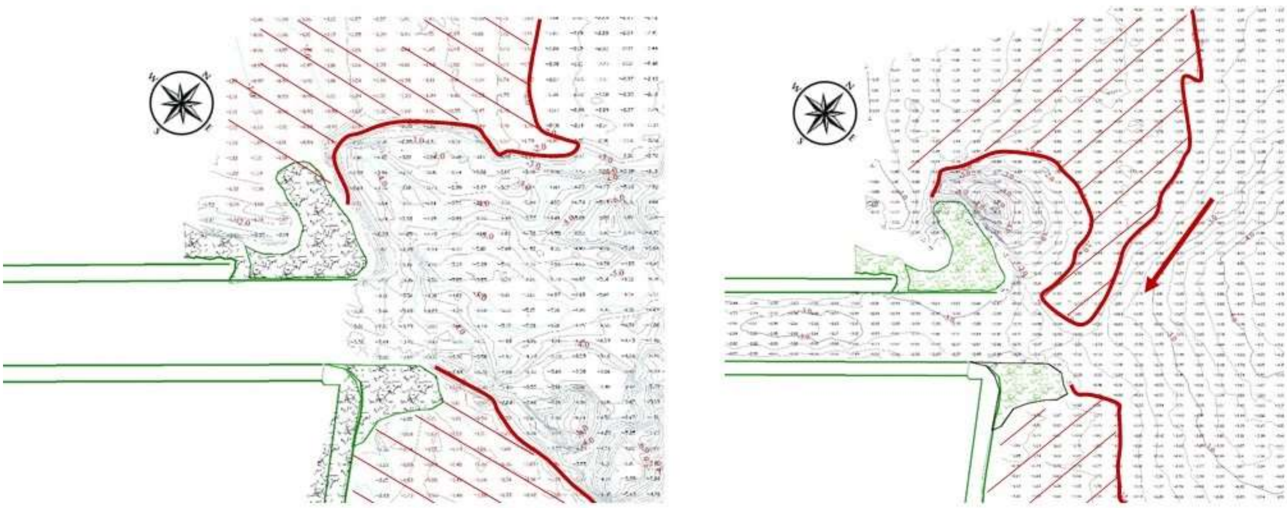

Figure 6. Example of bathymetry analysis: on the left the bathymetries after sediment handling through propellers (May 2009), on the right the bathymetries seven months later (December 2009). The red line indicates the – 2.00 meters of water depth.

Another relevant activities is the **analysis of dredging and other sediment handling operation carried out in the past**. The technological solutions adopted until now, including seasonal dredging and/or sand underwater re-suspension by boat propellers, as well as docks lengthening (completed in 2009), have not solved the sedimentation problem: as highlighted by Table 2, from 2009 to 2015 the Municipality of Cervia invested about 1.3 million Euro in dredging and sediment handling with propellers (i.e. a **mean yearly cost of 185,000 Euro**).

Table 2. Dredging and/or sediment handling through boat propellers or dredgers in Cervia harbour from 2009 to 2015.

Year	Month	Operation	Quantity (m^3)	Duration (days)	Cost (€)
2009	Jan-Feb	Dredging	20000	-	180,000
2009	May	Propellers	-	12	100,000
2010	Jan-Mar	Propellers	-	12	100,000
2011	Jan	Propellers	-	6	52,000

2011	Nov	Propellers	-	6	52,000
2012	Apr	Propellers	-	3	23,400
2013	May-Jun	Dredging	16950	-	150,000
2014	Feb-Apr	Propellers	-	4	20,000
2014	Feb-Apr	Dredging	51200	-	500,000
2015	Jan-Feb	Dredging	10000	-	-
2015	Apr-May	Dredging	23400	-	180,000

The main challenge in ejectors plant design phase is to identify the most critical area of sedimentation, since, as observed in the previous installations of ejectors plant, if sedimentation is avoided in that location, sediment settling process should not proceed in the sediment natural transport direction. Through this approach it is possible to maximise the efficacy of the ejectors plant by keeping the number of ejectors installed to a minimum, which is a relevant contributing parameter for the investment cost. Figure 7 shows how the demo plant was intended to work in the harbour inlet area: a first area of influence of about 30 m x 20 m (i.e. the rectangular area in Figure 7) is strongly influenced by ejector operation, while a second semi-circular area of about 40-50 m from first area's centre (i.e. the semi-circular area in Figure 7) is still influenced by ejector operation, but with longer timings. The demo plant achieves sand by-passing from the northern to the southern dock and avoids sedimentation in the harbour inlet. The sediment that is transported by the principal natural conveying direction or by relevant weather events like sea storms in the first area of influence is directly sucked in by the ejectors and discharged 60 m away from each ejector. That distance was chosen since it is the minimum required to get beyond the southern dock line. The sediment that is transported in the second influence area slowly slides towards the first area of influence. The expected impact of the demo plant is to avoid sedimentation at the harbour inlet through a sand by-pass system that pushes the sediment in the natural direction, i.e. the direction that the sediment would take if the docks were not installed.

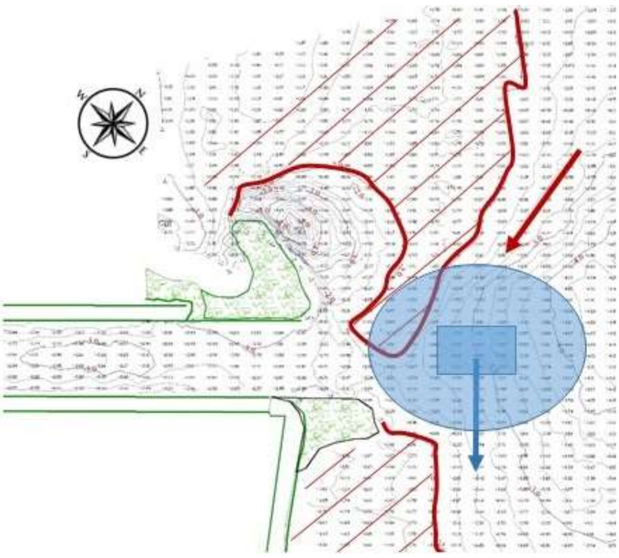

Figure 7. The expected impact of the demo plant on natural sediment transport.

A new version of the ejector was designed for the Cervia installation: in particular, the number of radial nozzles was optimised, and some modifications were also made to the internal part to reduce pressure losses and to simplify device assembling. The new version of the ejector was preliminary tested in the laboratory of the University of Bologna (Figure 8): inlet and outlet ejector stream pressures were measured by pressure gauges, while inlet and outlet volumetric flows were measured by level variation in the water and discharge tanks, respectively. Ejector performance is measured through the ratio between the secondary flowrate Q_S (i.e. the flowrate that is sucked in by the ejector, computed as the difference between discharge flowrate Q_D and primary flowrate Q_P) and the discharge flowrate Q_D. The primary flowrate includes both central nozzle and radial nozzle flowrates, but only the central nozzle is responsible for the suction capacity of the ejector. Moreover, the performance of the ejector was characterised based on the equivalent discharge pipe length, which was simulated in the laboratory by the opening/closing of a manual valve in the discharge pipeline. Different plant configurations were tested, resulting as a combination of the following variables: ejector central nozzle diameter, numbers of ejector radial nozzles, primary flowrate (controlled through a manual valve) and discharge pipeline length.

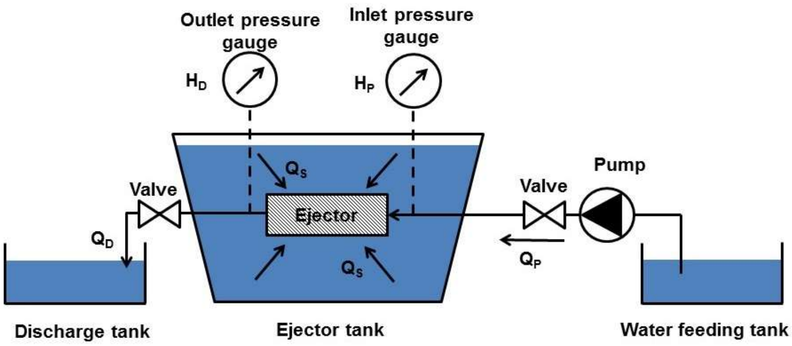

Figure 8. Laboratory testing equipment for ejectors.

Once laboratory trials have been concluded, two ejectors were tested in Cervia in July 2017. The ejectors were installed at the harbour inlet and were tested for 10 days in different configurations, while one ejector worked for 15 days continuously at a specific working condition. The field tests (Figure 9) were carried out with a similar approach to the laboratory one (Figure 8): two submersible centrifugal pumps were installed in the Marina of Cervia, each one pumping water to one ejector. The pressure was measured before the manual valve to estimate the primary flowrate based on the pump characteristic curve. The discharge rate was computed by measuring the filling time of a floating tank.

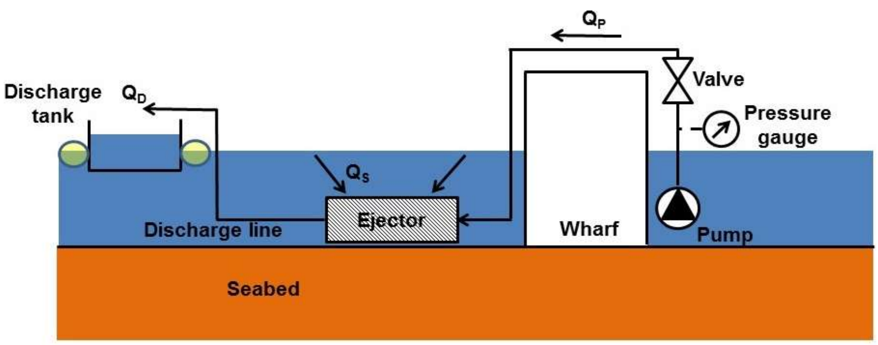

Figure 9. Field testing equipment for ejectors.

In particular, one selected ejector was tested for 15 days in the following operating condition: primary water feeding flowrate of about 27 m^3/h, working pressure of about 2.4 bar and a discharge pipeline characterised by 60 metres in length. This operating condition corresponds to a peak sand flowrate at the discharge pipeline of about 2 m^3/h (whole discharge flowrate is about 34 m^3/h) and a water pump power consumption of about 3.5 kW. After 15 days of continuous operation, the ejector, installed at a water depth of 2.6 m, was able to reach and maintain a water depth of 3.4 m. The measured influence area had a diameter of about 5-7 m. Obviously, such a working condition is not expected to be constant, and so the related power consumption of the demo plant was estimated to be considerably lower. In fact, by lowering the ejector primary water flowrate to 25 m^3/h it is possible to reduce both ejector suction capacity as well as power consumption. The plant operation can thus be adapted to the current environmental condition by controlling the primary water flowrate that is used to feed the ejectors.

The field test equipment is not much expensive and the testing period is not so long: the result is that **organizing a field test is not really expensive** (cost should stay in the range 10,000-20,000€ depending on local conditions, including assembly, disassembly and power consumption), especially if the equipment are rented by Trevi to the potential customer and discounted if the ejectors plant is sold. Nevertheless, it is important to underline that the organization of preliminary test is not mandatory for the effective implementation of a seabed maintenance management plan.

On the basis of ejector characteristics and preliminary tests results and sediment characterisation, **10 ejectors are needed** to cover such an area, which measures about 1,600 m^2. Based on historic bathymetry analysis, a mean yearly sediment rate of about 3,000-4,000 m^3 of sand can be expected in that area.

4.2 Definition of the objectives

The main target to be reached by the demo plant operation in Cervia was to guarantee a **minimum water depth of about 2.5 meters** at the port entrance of the Marina. Another target was to kept the operation and maintenance costs at a reasonable range, anyway lower than historical costs to produce an economic benefit for the Municipality. The **targeted energy consumption** was about **255,000 kWh per year**, which means about **55,000 € per year**. Maintenance costs were not easy to predict, and were assessed during the project.

4.3 Actions

From the very beginning the project consortium worked actively in **stakeholders engagement**. Figure 10 shows a map of the stakeholder involved during the demo plant realization and operation in Cervia. In particular, the **active involvement of local authorities is fundamental** to early address the permits procedures related with ejectors plant installation and operation. Based on the Italian law, ejectors plant operation does not need a dredging permit, which is a key point for the technology comparison with traditional maintenance dredging. On the other hand, several permits were necessary for the demo plant installation and operation, which involved:

- Cervia Municipality and the Region: permits and authorization for occupation of state-owned land;

- Province of Ravenna: opinion on landscape impact of the demo plant;
- Regional environmental agency (ARPAE): two technical opinion about dredging permit exclusion and wastewater discharge authorization exclusion;
- Coast Guard: technical opinion about marine installation and authorization for ejectors plant installation and maintenance activities (i.e. divers operation).

Community groups and end-users have been engaged through **public meetings** hosted by Cervia Municipality and by local associations, organized before and after demo plant installation.

Design, realization and maintenance of the ejectors plant mainly involve **suppliers and contractors engagement**, but also the contributions from customers and end-users can be useful.

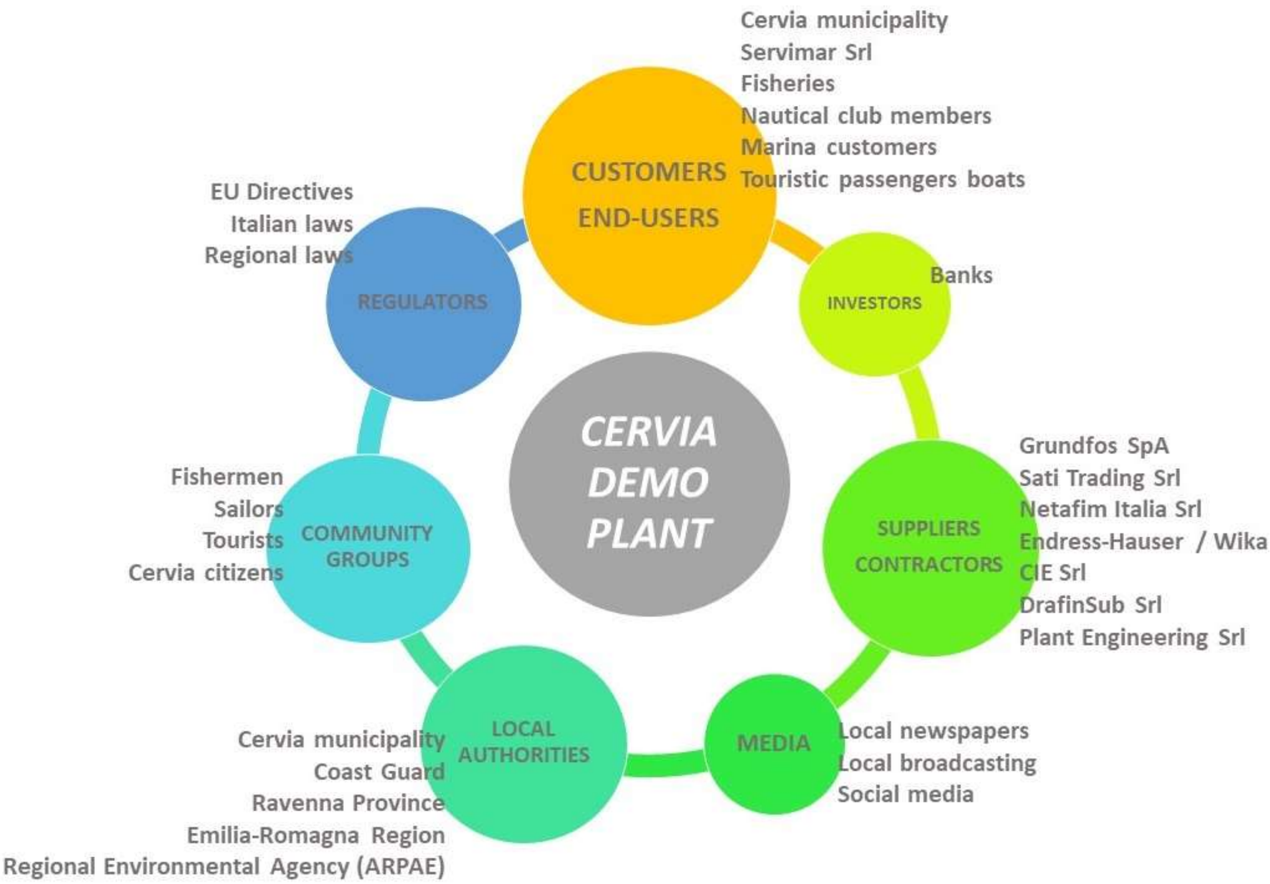

Figure 10. Map of the stakeholders engaged during Cervia demo plant design, installation and operation.

<u>4.4 Financing</u>

MARINAPLAN PLUS project partners were co-financed with a mean 57.67% percentage. For future applications, depending on business models, Trevi as service seller or the final customer as ejectors plant buyer should find the resources the finance design, installation and operation for 10 years of the ejectors plant. Own-financing capacity and/or the opportunity to find investors (i.e. banks) should be evaluated based on specific framework conditions.

4.5 Monitoring system

Great efforts have been put in the LIFE MARINAPLAN PLUS project to **monitor the impact** of demo plant operation. The first parameter to be assessed is the **water depth** in the area affected by ejectors operation as well as in the surrounding area. Water depth assessment should be made on a monthly based through **bathymetric measurements**. Demo plant operation and maintenance has been evaluated thanks to:

- **automatic monitoring system**, able to measure demo plant operation parameters, like **water flowrates** in each ejectors water feeding pipelines, **pressure** at the pumps outlet, **pressure drop** on the auto-purging filters, **power consumption**, plus **wind speed and direction** at the port inlet as ambient parameter related to marine weather;
- **site activities log**, to manually record all the maintenance activities and related costs (see Deliverable B2.1).

It has not been possible to assess the **impact on local economy due to navigability extension** all over the year since due the Covid-19 pandemic and the lock-down in the period March-June 2020 the potential benefits have been completely lost in terms of, for example, boat traffic increasing.

The environmental impact assessment of the demo plant has been performed by considering several parameters to evaluate the impact on **seabed integrity**, **noise** and **polluting emissions**:

- sediment characteristics,
- benthic macroinvertebrates,
- fish assemblages,
- underwater noise,
- GHGs and pollutants emission through LCA approach.

The results of the environmental monitoring actions are summarized in Deliverables C1.6 and C1.7.

5. Guidelines for stakeholder engagement

The dredging activity takes place at the interface of the water bottom formed by sediment and the water body, and due to the many connections with several areas of interest (land, water, waste, natural habitat, etc…) dredging always lead to fairly unique problems with the regulation of dredging and dredged material disposal. Dredging rules are also influenced by the specific environmental conditions and the history of dredging in a particular state/region. That's why the EU has not dealt specifically with dredged material regulations, nor does it currently intend to do so. This does not mean that European rules and regulations are completely irrelevant: legislation on waste and sludge has some bearing on dredged material, while environmental related Directives like the Habitats Directive and the Water Framework Directive bring constraints to dredging projects.

The need to dredge the bottom of water bodies in order to ensure navigation security or remove dangerous sediments has always been in contrast with: i) the classification of dredged material (waste or non-waste?), ii) the need for possible remediation measures in the same area, and iii) the reuse of sediments as a resource. The European Directive 2008/98/EC clarifies that "*sediments relocated inside surface waters for the purpose of managing waters and waterways or of preventing floods or mitigating the effects of floods and droughts or land reclamation*" are excluded from Waste Directive application. Nevertheless, all dredging operations are subject to environmental permits: more and more attention has been given to the environmental impact of dredging since the Water Framework Directive has been in place. The result is that dredging operations have become more difficult to plan and authorise.

From a technological point of view, it is clear that the ejectors plant operation cannot be equated to maintenance dredging. Nevertheless, since dredging regulation has national and, sometimes, regional rules, it is important to engage from the very beginning regulators and local authorities to obtain technical opinions from relevant bodies about the exclusion from dredging permits need of the ejectors plant operation. **One of the main barriers in technology innovation is usually the legislative barrier**: in this specific case, the main issue is how to define the operation of the ejectors plant, namely whether the demo plant operates as a dredge or not.

Since 21st September 2016, a new regulation about dredging operation has been in place in Italy (DM 173/2016). The main merit of the new regulation is that it clarified what can be considered as excluded from being authorised as a dredging operation, in. In particular, sediment "*movements in the harbour area and in the operations of restoration of the beaches*", "*movements in the harbour area*" were defined as "*handling of sediments inside harbour structures for the remodelling activities of the seabed in order to guarantee the moorings practicability, the safety of approach operations or the restoration of navigability, with methods that avoid dispersion of sediments outside the intervention site*".

Another issue regarding the ejectors plant operation was related to the Italian legislative definition of "*wastewater discharge*" (from D.Lgs. 152/06), which may involve a specific permit for the ejectors and ejector discharge duct installation, as well as for the filter discharge pipeline that is installed in the pumping station of the demo plant.

Both legislative issues were dealt with through a **pro-active and positive interaction** with the regional environmental agency (ARPAE), which is in charge of issuing both permits (dredging and wastewater discharge) for the demo plant installation and operation.

Other stakeholder should be involved in the development of the seabed maintenance management plan accordingly to Figure 11. Public meetings and planning conferences are the preferred tools to stimulate co-design and active participation of the stakeholder to be involved. Nevertheless, in some cases direct meetings can be more effective in reaching the objectives.

Figure 11. Seabed maintenance management plan structure and connections with stakeholder engagement strategies.