Project Monitoring Protocol

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

LIFE Environment and Resource Efficiency project
LIFE15 ENV/IT/000391

Start Date: 01/10/2016
Expected End Date: 31/12/2019

Type of Protocol: Public

Delivery date:
22/12/2016

Last update:
17/02/2017

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Chapter 1. Introduction

1.1 Introduction

The port of Cervia is interested by a cyclic problem of inlet silting. Relevant data are present about port bathymetries, in particular from 2009 and up to now. The technological solutions adopted in the past, including seasonal dredging and/or sand handling through boat propeller as well as docks lengthening (completed in 2009), didn't solve the problem.

The overall objective of the MarinaPlan Plus project is to apply and demonstrate at industrial scale an innovative and reliable technology for marine and coastal management able to ensure navigability and access to ports throughout the year, thus allowing at the same time thriving maritime economy and environmental sustainability. The technology avoids the usual collection of littoral materials nearby the entrance of harbors through the installation of submerged and static devices, called "ejectors", which are fed by pressurized water, aspire a mixture of water and sediments and convey it through a pipe in an area where does not constitute obstacle to navigation.

Demo plant environmental and socio-economic impacts on port of Cervia environment will be monitored through the planning of replicated targeted sampling campaign, the setting up of specific indicators, a collection of existing data on them, and space/time statistical analysis of the collected data. Furthermore, demo plant electric energy consumption and CO_2 and particulate emission will be assessed. Finally, communication and dissemination impact of the project will be assessed too.

1.2 Scope of the document

The scope of the document is to define the parameters need to be monitored during MarinaPlan Plus project lifetime, how they should be measured or estimated and when (timing and/or frequency), coherently with the "*LIFE project specific indicators*" Excel file (Annex 01). The final aim is to define how the environmental and socio-economic impact of the demo plant can be assessed, as well as the impact of communication and dissemination actions.

Chapter 2. Parameters Definition

2.1 Environmental Impact

a. Sea floor integrity

The European Marine Strategy Framework Directive (MSFD) requires European states to maintain their marine waters in 'Good Environmental Status'. The MSFD includes 11 descriptors of "Good Environmental Status" (GES), including "*Sea-floor Integrity*". This descriptor is defined as: "*Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected*".

Generally, due to the large variety of seafloor types, it is necessary to define indicators and standardized methods that can give a good image of the status of benthic ecosystems (i.e. living on the sea floor) and of their alteration by pressures from human activities. These indicators can be based on the presence of particularly sensitive habitats or on the composition and structure of the benthic assemblages. They can also include indices calculated from several parameters such as the species diversity, the number of species and the proportion of different species.

To assess possible impacts of the demo plant installation on sea-floor integrity a survey following a Before/After Control/Impact sampling design (BACI) will be carried out. The analyses to quantify the composition and abundance of the benthic assemblages will be done in the two control and one impact site, and after versus before the deployment of the demo plant. Three field campaigns will be carried out during the project (1 before the deployment and 2 after it). During each campaign replicated samples of the benthic assemblages will be collected in each area within each site. After a pre-sieving (0.5 mm mesh) in the field, samples will be preserved using a buffered solution of 4% formaldehyde. In the laboratory specimens will be identified to the lowest possible taxonomic level, using a binocular microscope, and the number of individuals counted. Species richness (as number of taxa, S) and Shannon's diversity index (H' based on log2) will be calculated for each replicate sample. Differences in species abundance and species diversity indices will be analysed by ANOVA, in accordance with the experimental design. Similarity between assemblages among the study sites and times will be analysed using principal coordinate analysis (PCO, i.e. metric multidimensional scaling) based on Bray–Curtis dissimilarities of square root transformed data. Differences will be assessed by a distance-based permutational multivariate analysis of variance (PERMANOVA) following the same multi-factor experimental design used in the ANOVA, including all contrasts and partitions involving impact and control locations. Furthermore, to assess patterns of environmental quality in the impacted and control sites the AZTI's Marine Biotic Index (AMBI) index will be used. AMBI values, calculated with the software AMBI ver. 4.0, are based on species sensitivities. In the AMBI framework, species are assigned to five ecological groups based on their sensitivity to environmental stress. Values of the AMBI index will be used to compare the environmental quality between impacted site and control condition. AMBI has a reference scale of classification defining the ecological status in five classes (high, good, moderate, poor, and bad, according to the requirement of the EU directives).

To assess possible impacts of the demo plant installation on fish assemblages a survey using the visual census techniques will be done following the experimental design described before. The species diversity and abundance of fishes per area will be estimated by counting the number of individuals in the area over the observation time. Data will be analyzed using univariate and multivariate statistical tools. This approach allows to discriminate the potential additional stress caused by the installation of the demo plant from the background levels of anthropogenic pressures. Based on the quantification of the possible changes in the fish assemblages, appropriate mitigation measures will be suggested.

b. Bathymetry

Bathymetry is the study of underwater depth. Two meters mean tide level (MTD) of water depth in front of Cervia Port inlet is the minimum level under which Cervia municipality has to organize sediment removal by dredging or sediment handling by propellers. The aim of the project is to guarantee through the application of a novel technology a water MTD a minimum of about 2.5 meters at Port inlet, thus favoring navigation all over the year. A historical database is present in Cervia municipality about water depth variation in the proximity of port inlet. Bathymetries were realized through georeferenced echosounder (echo GPS), approximately three times a year.

The same measuring method and frequency will be maintained during demo plant operation. Local bathymetries, near ejectors installation, will be made manually for a more frequent observation of their impact.

c. Monitoring of chemical-physical characteristics of the sediment

The sediment characteristics of Cervia Port inlet are yearly monitored by Cervia municipality. A historical database is present in Cervia municipality about chemical-physical analysis of the sediment present in the port area.

Before and after the realization of the preliminary on-field tests as well as the operation of the demo plant, the sediments characteristics will be measured. In particular, sediment samples will be analysed to evaluate physical (grain size, moisture content, specific weight), chemical (content in mercury, cadmium, lead, arsenic, total chromium, copper, nickel, zinc, total hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, total organic matter, total nitrogen, total phosphorus, aluminum) and microbiological features (total coliforms, fecal coliforms, fecal streptococci, salmonella, spores sulphite reducing clostridia and in the case of materials destined to beach nourishment, enterovirus and fungi). The analysis will be carried on coherently with the Italian legislation, which defines what sediment characterizations are necessary and how to evaluate dredged sediment disposal routes (beach nourishment, open-sea discharge, landfill). Analysis will be carried out by ARPAE, the environment agency of Emilia-Romagna.

The assessment will be useful to measure the impact of the demo plant on water quality: turbidity, suspended solids, and other variables that affect light transmittance, dissolved oxygen, nutrients, salinity, temperature, pH, and concentrations of trace metals and organic contaminants if they are present in the sediments.

d. CO_2 emission

The assessment will be realized through an estimation of both CO_2 emissions from diesel engine (in case of dredging and propellers operation) and CO_2 equivalent emissions due to electric energy consumption of the demo plant. The dredge realizes a negative impact in the local environment due to CO_2 emission from diesel engines that feed both dredging element and boat (i.e. between 6,5-11,7 kg CO_2eq per ton of sediment removed). (Aumônier et al., 2010. Carbon footprint of marine aggregate extraction). The substitution of dredge with the demo plant should reduce consumption (CO_2 emissions are estimated by considering an emission factor of 376 gCO_2/kWh el). Moreover, the CO_2 emissions are not concentrated near the Port, but distributed (since the demo plant is fed by electrical energy). The use of water pumps regulated by inverter also gives benefit in terms of electrical energy consumption and so on CO_2 emission.

e. Particulate emission

The assessment will be realized through an estimation of both particulate matter ($PM_{2,5}$) emission from diesel engine (in case of dredging and propellers operation) and $PM_{2,5}$ equivalent emissions due to electric energy consumption of the demo plant. The dredge realizes a negative impact in the local environment due to particulate and pollutants emissions from diesel engines that feed both dredging element and boat (i.e. about 9 g of $PM_{2,5}$ per ton of sediment removed, reference: Aumônier et al., 2010, Carbon footprint of marine aggregate extraction).
The substitution of dredge with the demo plant reduces consumption (particulate emissions are estimated by considering an emission factor between $7{,}09 \times 10^{-3}$ to $3{,}71 \times 10^{-2}$ g $PM_{2,5}$/kWh el, reference: Buekers et al., 2014, Health and environmental benefits related to electric vehicle introduction in EU countries). Moreover, $PM_{2,5}$ emission is not concentrated near the Port, but distributed (since the demo plant is fed by electrical energy).

f. Underwater noise level/frequency

The marine installation of the plant can produce underwater noise: in particular, the noise may be produced by the ejectors, since they produce a water jet with a 2-4 bar pressure. At the moment, the baseline underwater noise can be estimated to be around 80 dB on the basis of literature data. It is not possible to estimate the noise impact of ejectors, even if it can be assumed that not relevant changes in the underwater noise level baseline should be observed once the plant will be in operation (so, dB increasing in the field 5-15 dB). On the other hand, the ejectors underwater noise (if any) will be considerably lower with regard to the dredging underwater noise, which has a peak of about 170-190 dB re 1 µPa2m2 at around 50 Hz (Richardson, W. J., Greene, C.R., Malme, C.I. & Thomson, D.H., 1995, Marine Mammals and Noise, Academic Press, San Diego; Simmonds, M. P., Dolman, S. & Weilgart, L., 2004, Oceans of Noise), so an increasing with regard to baseline of about 100 dB. A hydrophone will be used, accordingly to international standards, to measure the underwater noise before and after plant installation. Appropriate reference standard will be identified, based on literature survey, for evaluating the impact of the plant measured in dB re 1 mPa^2/Hz through a measurement campaign realized both before and after the plant installation and in comparison with dredge noise.

g. Electric energy consumption

Electric consumption of the demo plant will be monitored to be able to calculate the energetic impact of the demo plant.

2.2 Economic Impact

A mean baseline can be defined for the Cervia seabed maintenance, which includes one sediment handling through propellers every 12 months (budget of about 57.900€ for each operation) and one dredging operation every 15 months (with a sediment removal of about 24.000 m^3, with a budget of 8,8 €/m^3). So, a yearly cost of about 225.000€ can be estimated for Cervia seabed maintenance. Project objective is to reduce yearly seabed maintenance cost to about 100.000€, with a reduction of 55%. Cost decreasing can be reached through the minimization (up to complete avoiding) of dredge operation and a more localized use of propellers.

h. Running/operating costs

Running/operating costs are due to two main costs: energy consumption (as described before at point g.) and maintenance (ordinary and extraordinary). Maintenance are directly related to the total number of hours spent on maintenance activities, both programmed and extraordinary, and the cost of parts of replacement. Expensive extraordinary maintenance may be needed due to clogging or other malfunctions. Operating costs are included in this category, covering the employment necessary for the normal operation of the system pumping. These costs include, for example, the normal wear, the supervision of the system and the cleaning of the pumping station. All costs of the system maintenance will be included, also the various displacements due to technical staff and the various contingencies that may arise during installation and normal operation. A maintenance schedule will be realized to take track of every maintenance interventions.

i. Capital cost

Capital cost is related to the design, realization, installation and commissioning of the plant. Capital cost will be adequately accounted to have at the end of the project the total budget spent in the realization of the demo plant.

2.3 Social Impact

Usually, there are certain periods, which frequency and duration are affected by seasonal variations and on local conditions, where the access to seaport is not allowed because water depth is not sufficient for safe navigation. This fact results in a critical condition for all the economic or social activities related to navigation, like fishing, maritime transports, tourism, since these activities can be partially or in the worst condition completely stopped, with clear impact on big and SMEs, workers and citizens. The negative impacts are higher for those contexts where dependency on commercial and/or touristic activities related to the seaport is higher, since in these cases the limitation on navigability can have great negative impacts also on the economic induced.

l. Jobs

Two young researchers (under 35 years) employed for project duration by University of Bologna (4 years FTE). One engineer/architect employed by Comune di Cervia (3 years FTE). After project end, a business model can be developed by Trevi, thus up to 5 FTE new workers can be foreseen.

m. Socio-economic indicators

Relevant parameters to be monitored will be: percentage of berths occupation, days/year of fishing, number of boaters per season. These parameters will be monitored before and after demo plant functioning also through the involvement of port stakeholders.

2.4 Communication and Dissemination Impact

n. Website impact

Total number of website individuals, visits and interactive contacts will be monitored.

o. Press conference

Number of individuals (journalists and stakeholders) taking part to press conference.

p. Newsletters

Number of individuals reached by the newsletters.

q. Exhibition

Number of visitors.

r. Publication and brochure

Copies of publications and brochures distributed, numbers of scientific publication views and download.

s. Networking

Number of individuals involved in MarinaPlan Plus workshops and conferences.

t. Governance

Number of NGO involved in the project.

u. Replication

Number of new project and new geographical areas of interest.

2.5 Summary of parameters and project actions

Table 1 is a summary of the parameters to be measured or assessed, and the related actions wherein an impact can be measured. Underlined key indicators and parameters are in addition to the ones included in the "*LIFE project specific indicators*" Excel file.

Table 1. Key indicators and parameters and actions wherein they have to be measured or assessed.

Impact	**Key indicators and parameters**	**Actions**							
		A1	B1	B2	B3	C1	D1	D2	E1
Environmental	Sea floor integrity			X					
	Water depth	X		X					
	Sediment chemical-physical analysis	X		X					
	Particulate emission			X					
	Electric energy consumption			X					
	Underwater noise			X					
	CO_2 emissions			X					
Economic	Running/operating costs			X					
	Capital cost		X	X					
Social	Jobs	X	X	X	X	X	X	X	X
	Socio-economic indicators			X					
Communication Dissemination	Implication of NGO						X	X	
	Website indicators						X		
	Press conference						X		
	Newsletters						X		
	Exhibition						X		
	Publication						X		
	Brochure						X		
	Scientific publication						X		
	Networking						X	X	
	New projects							X	
	New geographical markets							X	

Chapter 3. Monitoring protocol planning

Table 2 summarizes timing and frequency of key indicators and parameters measuring or assessment depending on MarinaPlan Plus project actions.

Table 2. Description of timing and frequency of key indicators and parameters measuring and assessment on the basis of project action.

Key indicators and parameters	Action	Description	Timing/frequency	Delivery on PSI excel	Partners in charge
Sea floor integrity	B2	Preliminary measurement before demo plant starts running.	Indicatively May-June 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
		Two measurements after demo plant running for at least 6 months.	May-June 2018/2019	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
Water depth	A1	Preliminary measurement before on-field test starting.	December 2016	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
		One measurement after test completion.	March 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
	B2	Preliminary measurement before demo plant starts running.	Indicatively May-September 2017	☐ 04/17 ☐ 05/18 ☐ 05/19	Cervia

				☐ 12/19	
		Three measurements after demo plant running.	January 2017 July 2017, January 2018	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
Sediment chemical-physical analysis	A1	Preliminary measurement before on-field test starting.	December 2016	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
		One measurement after test completion	March 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
		One measurement of ejector discharge during functioning	January-March 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
	B2	Preliminary measurement before demo plant starts running.	Indicatively May-September 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia
		One measurement after demo plant running.	Indicatively April-October 2018	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Cervia

Particulate emission	B2	Continuous monitoring of electric energy consumption and estimation of particulate emission.	From October 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
Electric energy consumption	B2	Continuous monitoring of electric energy consumption.	From October 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
Underwater noise	B2	Preliminary measurement before demo plant starts running.	Indicatively April-September 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
		One measurement after demo plant running.	Indicatively April-September 2018	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
CO_2 emissions	B2	Continuous monitoring of electric energy consumption and estimation of CO_2 emission.	From October 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
Running/operating costs	B2	Continuous monitoring of electric energy consumption. Daily up-date of maintenance sheets to take trace of any kind of interventions on the demo plant (workers, technicians, sub personnel, …). Daily mapping of spare parts use and equipment and/or consumables substitution.	From October 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi, Unibo

Capital cost	B1	Evaluation of design costs.	From April 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi
	B2	Evaluation of installation and commissioning costs of demo plant.	From July 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi
Jobs	All	Continuous monitoring of new jobs created within project consortium.	From October 2016	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
Socio-economic indicators	B2	Preliminary monitoring before demo plant starts running.	Indicatively May-September 2017	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo, Cervia
		Monitoring after demo plant running.	Indicatively April-October 2018	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo, Cervia
Implication of NGO	D1, D2	Monitoring of contacts.	Monthly	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Unibo
Website indicators	D1	Monitoring of website performances.	Monthly, starting from March 2017	☐ 04/17	Trevi

				☐ 05/18 ☐ 05/19 ☐ 12/19	
Press conference	D1	Signs and contacts of people involved.	For each	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
Newsletters	D1	Contacts.	Monthly	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi
Exhibition	D1	Signs and contacts of people involved.	For each	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
Publication	D1	Number of copies distributed.	For each	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
Brochure	D1	Number of copies distributed.	For each	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
Scientific publication	D1	Monthly monitoring of number of views and downloads.	Monthly, starting from publication date	☐ 04/17 ☐ 05/18	Unibo

				☐ 05/19 ☐ 12/19	
Networking	D1, D2	Signs and contacts of people involved.	Twice a year	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	All
New projects	D2	New projects contacts.	Twice a year	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi
New geographical markets	D2	New markets contacts.	Twice a year	☐ 04/17 ☐ 05/18 ☐ 05/19 ☐ 12/19	Trevi

The "*LIFE project specific indicators*" Excel file will be updated coherently with the timing foreseen in the MarinaPlan Plus proposal.