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Support the establishment of the MED-ECA: The LIFE4MEDECA project

Elena Ciappi[a*], Elena Paifelman[a], Holger Kramer[b], Kare Press-Kristensen[c], David Greniman[d], Adriano Mariani[e], Suzan Kholeif[f], Riccardo Di Meglio[g], Pedro Arnau[h]

[a]*CNR-INM, Via di Vallerano 139, Roma 00128, Italy*
[b]*Institute of Shipping Economics and Logistics, Universitatsallee 11-13, Bremen 28359, Germany*
[c]*Green Transition Denmark, Kompagnistraede 22, Copenhagen K 1208, Denmark*
[d]*MD International ltd, Yehuda ha-Nasi St 90/2, Herzliya 46448, Israel*
[e]*Unimar Società Cooperativa, Via Nazionale 243, Roma 00184, Italy*
[f]*SDG4MED, Corso Sicilia 71, Catania 95131, Italy*
[g]*Autorità di Sistema Portuale del Mar Tirreno Settentrionale, Scali Rosciano 6/7, Livorno 57123, Italy*
[h]*CIMNE, Gran Capitan S/N, Barcelona 08034, Spain*

Abstract

The ongoing process for the creation of an Emission Control Area (ECA) for the Mediterranean has already received the endorsement of all Mediterranean national governments. The designation of an ECA for Sulphur Oxides (SO_x) and for Nitrogen Oxides (NO_x) could, by 2030, cut emissions of SO_x and NO_x from international shipping by 80% and 20%, respectively. This would lead to the avoidance of more than 4000 cases of premature deaths annually by 2030. Furthermore, the entry into force of the MEDECA will play an important role in the protection of marine and coastal biodiversity and of cultural heritage. The effects of the fuel shift for maritime transport need to be carefully considered in order to estimate the economic and social impact and to identify the most appropriate tools and policies to alleviate the cost. The LIFE4MEDECA project is aimed to support the whole process.

Keywords: MED SECA; Health; Biodiversity; ULSFO spill; Scrubber; Cultural heritage.

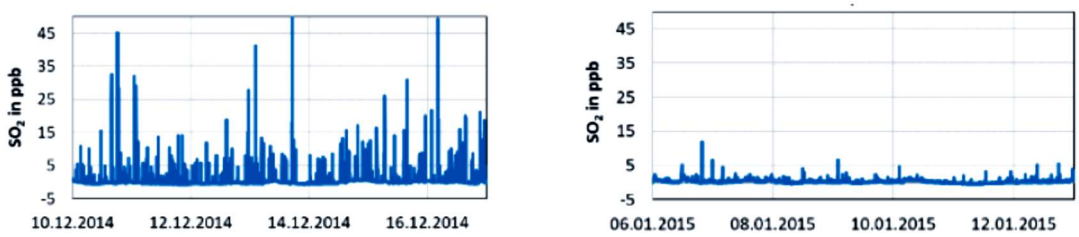
1. Introduction

The 22nd Meeting of the Contracting Parties (COP 22) to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and its Protocols, held in Antalya,

* Corresponding author. Tel.: +39-06-50299268.
E-mail address: elena.ciappi@cnr.it

on December 2021 (UNEP/MED 2021), agreed on the designation of the Mediterranean Sea, as a whole, as an Emission Control Area for Sulphur Oxides (Med SO_x ECA in the following indicated as SECA) to be requested at the International Maritime Organization (IMO) meeting in 2022. It was also agreed to start the discussion about the establishment of a Control Area for Nitrogen Oxides (NECA) in the next two years. The SECA shall be in force in January 2025 and will join the already established North American, Caribbean, Baltic and North Sea ECAs. The experience from the North European ECA, established in 2015, demonstrate that in coastal areas SO_2 concentration generally decreased by more than 50% (see Fig.1), indicating that shipping was a key source of pollution and that the SECA solved the problem. It has also been estimated that the annual health benefits of SECA amount to € 4.4-8.0 billion, which is much higher than the cost of its implementation (LIFE4MEDECA 2021).

Fig.1 SO_2 levels in North Germany before and after SECA establishment



A recent air quality study performed in five Canadian major port cities, showed that SO_2 concentrations significantly decreases at all sites (−28% to −83% mean hourly change) after the SECA came into force in 2015. Statistically significant $PM_{2.5}$ but smaller fractional reductions were also observed (−7% to −37% mean hourly change), reflecting the importance of non-marine PM sources (see LIFE4MEDECA 2021 and references cited herein).

The Mediterranean is one of the world's busiest seas with about one third of the world's total merchant shipping (above 100 Gt) operating within major maritime transit routes. From an environmental point of view, Automatic Identification System (AIS) data shows that roughly 30.000 vessels are operating annually in the Mediterranean accounting for about 7% of global maritime transport emissions and for about 10% of the Mediterranean coastal states CO_2 inventories. The Mediterranean Sea covers about 2.6 million km^2 and it is surrounded by 22 countries from Europe, Africa, and the Middle East with around 480 million residents of which about one-third concentrated along its coastal regions. Cofala et al. (2018) estimated that the designation of an ECA under MARPOL in the Mediterranean Sea could, by 2030, reduce SO_x and NO_x emissions from international shipping by 80% and 20%, respectively. This could avoid more than 4000 cases of premature death per year by 2030 and up to 10000 cases by 2050.

The large number of countries bordering the Mediterranean, belonging to three different continents and characterized by a strong heterogeneity from a cultural, social, economic and political point of view, makes the process of setting up the ECA and its implementation more complicated than for other basins, requiring much attention to manage the complexity and to consider all different needs.

To comply with the SECA, the maritime industry has three alternatives: *i)* switching to compliant 0.1% Sulphur fuels, *ii)* install an Exhaust Gas Cleaning System (EGCS) known as scrubber or *iii)* use alternative low or zero Sulphur fuels (e.g. Liquefied Natural GAS-LNG or biofuels).

The feasibility and impact of different solutions have been analyzed in specific studies (IMO 2019a, IMO 2019b, Cofala et al. 2018, Farenc 2021, LLC(EERA) 2020), the main concern being the change in demand for fuel and therefore its cost. In general, the cost of fuel represents 30-60% of operating costs, and an increase in fuel costs may lead to higher charges for freight and passenger transport and to possible modal shift or re-routing.

The modal shift from freight and passenger transports to land-based modes is analyzed in Farenc (2021). Key variable is the price difference between Ultra Low Sulphur Fuel Oil (ULSFO) and the oils actually in use. In the study it is demonstrated that mainly intra-Mediterranean RoRo-services would be affected, depending on the routes and on the alternative on land, with assumed variations in freight tariffs between 1% and 8%. Except for few routes for example between Spain and Italy, the cost of container freight rates would have to increase by a factor of 1.6 to 4.3 before land-based transport modes become competitive in terms of prices.

On the other hand, intercontinental routes cross the Mediterranean for a small portion of the total trip and, therefore, the higher cost of fuel has little impact and it is not comparable to the operational cost of circumnavigating Africa.

Regarding potential distortions of competition and thus potential impact on competitiveness of Mediterranean ports, no evidence for significant re-routings of maritime transport due to fuel price increases occurred as many other factors are to be considered including other shipping operating costs, ports' infrastructures, efficiency, connectivity etc. (LLC (EERA) 2020). It is also shown that for intercontinental services, in line with the conclusions of Farenc (2021), any alternative routing via Cape of Good Hope instead of passing through the Suez Canal would take 12 more days implying additional costs for equipment and crew that balance out the higher fuel costs in the Mediterranean.

Although ULSFO is still considered a niche product, its availability is not considered a problem since refinery sector has increased capacities and productions to meet changes in fuel demands. Moreover, as stated in Clear Seas (2020), a study on SECA impacts on shipping in Canada's Pacific Region, the price gap between ULSFO and regular fuel is decreasing after the 2020 Sulphur Cap. Finally, in Cordina et al. (2020), the results of a study performed at national level to analyse the socio-economic impact of the MED SECA in Malta are reported.

In this paper the objectives of the LIFE4MEDECA project, the methodologies designed for their achievement as well as the results of scientific, technical and socio-economic preliminary analyses carried out in the first part of the project are presented. Based on the review of available studies regarding the Mediterranean basin (see references above) and on the experiences gathered from other ECAs (LIFE4MEDECA 2021), the main needs and bottlenecks related to the establishment and implementation of the SECA have been identified. In particular, the review highlighted the need for further analyses to assess the impact of the SECA on marine and coastal ecosystems, on cultural heritage and in turn on cultural tourism and on the port system. To this end, specific studies have been carried out to *i*) foster and support further scientific and technological developments, *ii*) suggest new regulations, *iii*) facilitate the development of plans to overcome infrastructural gaps and to *iv*) define appropriate economic and non-economic indicators for assessing the potential benefits of the ECA.

2. The LIFE4MEDECA project

On January 2021 LIFE4MEDECA, a preparatory action to support the establishment of the ECA in the Mediterranean and to build consensus and awareness among stakeholders, citizens and institutions, has been funded under the LIFE program. The project, co-funded by ministries of four different countries, namely Italy, France, Spain and Netherlands, is coordinated by the Port Authority of the Northern Tyrrhenian Sea, leading a consortium of 8 partners of which six from the Med area and two from the north Europe. These last had actively participate in the establishment and implementation first of the Baltic SECA and then of the Baltic NECA. The partnership provides expertise in the fields of engineering and computer sciences, life and natural sciences, economics as well as law and maritime policy. A broad range of skills is in fact necessary to manage the complexity of the process and analyse all the environmental and socio-economic implications performing multidisciplinary and multi-objective studies and activities capable considering diverse aspects and their mutual interactions.

To reach the aims of the project specific actions and tools were designed. To support and facilitate the establishment and implementation of the Med SECA, preliminary activities are devoted to:

- *Complete the knowledge gathering based on current understanding and studies in synergy with the work being undertaken internationally under the coordination of REMPEC*. Source of information have been REMPEC and IMO official documents and reports, studies commissioned by EC to different organizations, studies promoted by countries, results of past projects and scientific publications. Moreover, the operative perspective of ongoing projects allowed to gather additional information on recent achievements and suggestions about further needs. The same type of information regarding other ECAs was also collected. It is important to underline that networking with other projects and relevant initiatives is important not only for complementing the input but also to ensure alignment and coordination and to promote joint actions on relevant topics.
- *Establish a diverse 'reference' group of stakeholders*, of all Mediterranean countries including those of the southern shore to engage them in dedicated events and consultations at national and MED level to gather relevant additional knowledge, to identify further needs, to facilitate transfer of best practices and to dialog with and across industry. In addition, to assess possible cost impact mitigation including through EU funding opportunities. At this regard, the coordinators of relevant projects and initiatives active on the Mediterranean Basin were also

invited to convene to share relevant inputs, not only from a thematic point of view but also with regard to the supporting instruments they are using for developing actions that are of interest for the Med ECA.

These two actions are both aimed at identifying needs, bottlenecks and barriers to the designation of the MEDECA. Moreover, the reference group of stakeholders will provide inputs for the subsequent actions and feedbacks about the development of the process across the entire duration of the project. The second phase of the project is dedicated to:

- *Carry out additional studies and socio-economic impact assessments* on shipping and other relevant topics such as port infrastructures, cultural heritage, tourism, marine and terrestrial biodiversity protection. Based on available data, these activities will comprise the entire Mediterranean or will be focused on selected test cases;
- *Develop MEDECA scenario* quantifying costs and additional benefits. Most of the input for this analysis will come from previous activity (see section 4) and from specific requests by European Community;
- *Provide expertise for financial and legislative governance support* of the MEDECA Countries. This activity, strongly connected with the previous two, is aimed to identify tools and policies for the implementation of the SECA and to alleviate the cost of the process.

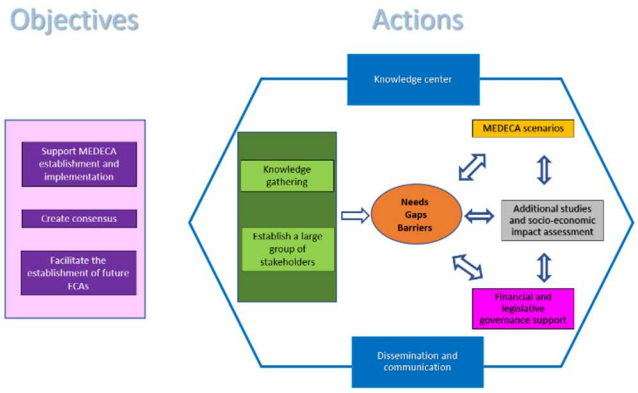
To contribute to the creation of a broad consensus a significant part of the project's activities is devoted to:

- *Disseminate and communicate benefits of the MEDECA* and the results of the project to citizens, local authorities and stakeholders. In addition to workshops, press conferences, and the organization of or participation to thematic events, conferences and the use of social networks and of websites, an important part of the communication activity is linked to the execution of air quality measurements in the main Mediterranean ports with the involvement of citizens, associations, local authorities. Up to date, measurements have already been carried out in Italy (Livorno, Piombino, Civitavecchia ports), Malta and Barcelona.

All the material gathered and produced within the project, regarding the establishment and implementation of the MED SECA, as well as of the other ECAs, will be organized in a virtual Knowledge Centre. The objective is not only to create a public database which will be updated beyond the end of the project, but also to build a platform for the exchange of information and news, managed by project partners and stakeholders.

The workflow of the project is summarized in Fig. 2.

Fig.2 LIFE4MEDECA workflow



3. Identification of specific Mediterranean needs

During the first year of the project, LIFE4MEDECA partners, based on available relevant studies and documents and the results of past and ongoing projects, and also considering the suggestions and needs of stakeholders, identified and selected a first set of key topics that were subject to analysis, the preliminary results of which are described in the following sections.

As it is frequently pointed out in official documents concerning the establishment, implementation and monitoring of ECAs, the reduction of SO_x emissions not only has a huge impact on the health of citizens, but also generates significant environmental benefits. Sulphur emissions contribute to the acidification of soil and waters in the form of dry and wet deposition resulting in the loss of biodiversity, forest degradation, lower agricultural productivity and

acidification of river, lakes and ground water. The effects should be more visible near the sources for instance around ports but, according to the results of the most sophisticated transport models, shipping emissions can travel over long distance (hundreds of km) thus potentially affecting coastal and inland regions. The topic has been studied in the past at European and global level in relation to emissions generated by industrial activities. The results of the studies showed the presence of plants and crops particularly sensitive to the effect of Sulphur deposition. Conversely, over the last 15-20 years this topic has received less attention because of the decrease in this type of emissions due to control policies and the use of greener technologies. However, in very recent times a renewed interest is observed, especially in Northern Europe, related to the need to assess the effect of SECA and NECA establishment in the Northern Seas (Repka et al. 2021). Preliminary results reported a decrease in acidification in the Baltic region, but specific biodiversity data are lacking. Therefore, scientific studies focused on the correlation between shipping emissions and acidification of coastal areas would be needed. With reference to the Mediterranean region, it would be important to analyze the impact on agriculture and quantify the socio-economic benefits of the Med SECA.

Mediterranean area presents some peculiarities with respect to all the already established ECAs which are worth to be considered. The rich history of the Mediterranean region has left a wide variety of sites that testify its diversity in terms of cultural and natural heritage. In 2019, 30% of all the UNESCO sites in the world were located in the Mediterranean basin which includes 339 sites in 36 countries. It is thus of specific interest to evaluate the impact of the Med SECA on historical buildings and monuments in ports and coastal cities. This issue, as discussed in section 4.3, has in turn effects on one of the main economic activities of the area, that is, on tourism.

Moreover, considering that *i*) the Mediterranean is one of the busiest sea in terms of shipping traffic *ii*) accidental oil spills due to accidents, although showing a decreasing trend over the last 20 years (Polinov et al. 2021) continue to occur with catastrophic effects on the unique marine biodiversity of the MED and *iii*) information about the behavior of Low Sulphur Fuel Oils (LSFO) at sea and on the efficacy of the remediation strategies are scarce, it is important to carry out specific studies on the behavior of LSFO when spilled at sea.

Finally, in view of the entry into force of the SECA, it is also urgent to identify possible critical issues that could hinder or delay the process in order to find the most appropriate solutions in a short time. Among these the capacity of the Mediterranean ports to manage the residual waters of ships equipped with scrubbers was considered. As outlined in section 4.2 this topic is also strongly related with the protection of the marine environment.

4. Additional environmental and socio-economic impact assessment: outcomes of the first-year project

4.1. Operational aspects in case of LSFO spill

The use of LSFO is a solution adopted by a significant number of ships travelling in ECAs (Clarkson Research 2021). LSFO have a highly variable composition, due to their relative recent introduction to the fuel market, information regarding the properties and behavior of these fuel oils is scarce.

Recently, some studies (Hellstrom 2017, Sørheim et al. 2020, Jonander et al. 2020) have been conducted worldwide to analyze the chemical and physical properties of different LSFO also as a result of the first major spill of VLSFO (very low sulphur fuel oil) occurred in 2020 in an environmentally sensitive area off Mauritius where 1000 tons of VLSFO were spilled into the warm Mauritius sea. Laboratory tests have been carried out by a research team (Scarlett et al. 2020) to evaluate main oil characteristics and assess its toxicity.

At present, no general and rigorous conclusions can be given because: *i)* the available studies were conducted on a limited number of fuel samples, mainly VLSFO, since ULSFO samples were provided only by few refineries, *ii*) most of the studies were carried out under conditions typical of the Arctic region and northern seas and *iii*) their toxicity was evaluated with respect to few marine species. However, from the results reported in the references above and detailed in LIFE4MEDECA (2022) it is possible to list some preliminary and common characteristics of VLSFO and ULSFO: 1) variable and high pour point, 2) lower viscosity with respect to traditional heavy fuel oils, 3) high variability of Polycyclic Aromatic Hydrocarbon (PAH) content generally a bit lower than that of heavy fuel oils, 4) low toxicity even if some long-term effects were observed in Jonander et al. (2020). Considering these characteristics, it is possible to conclude that remediation strategies with particular relevance to mechanical recovery can become challenging due to the high pour point of these oils. It is thus necessary to test available remediation strategies or design new technological solutions to be prepared in case of accidents and consider suggesting new regulations to

define an upper limit for the pour point. Specific studies focused on Mediterranean scenario and further toxicity analyses shall be performed as well. New insights for the Mediterranean are expected in the near future from the results of the EU IMAROS project (www.kystverket.no/imaros). Finally, from an economic point of view, it is important to underline that, in addition to direct costs related to remediation, estimated in the order of € 8800/ton for Italy (LIFE4MEDECA 2022), there are indirect costs connected to the suspension of activities at sea, in particular fishing and aquaculture, and economic activities related to the sea such as tourism. Indirect costs can be much higher than those related to remediation so it is crucial to be prepared to act promptly with effective clean-up strategies.

4.2. Port reception facilities for scrubber's residuals

Wet scrubbers are devices build in ship chimneys to filter engine exhaust smoke through water cleaning system. They can be divided in three different type namely *closed loop* that gather the contaminated residues on board and depollute the waste in ports, *open loop* that use the discharge into the sea to dispose of contaminated scrubber waste and are therefore a major source of pollution to the marine environment and *hybrid* scrubbers. According to Clarkson Research (2021) data, the relevant total worldwide operating fleet comprises around 81.000 vessels of which a total of 4.159 are equipped with scrubbers. Based on AIS data, out of all scrubber-equipped ships, 1020 spent at least 10% of their trip in the Mediterranean of which 0,9% are equipped with close loop scrubbers, 63% with open loop and 22,6% with hybrid scrubbers. Information about the remaining 13,4% are not available. RoRo ships, car carrier and cruise vessels have the highest shares of scrubbers in the Mediterranean. Similar figures hold for ships on order.

According to Osipova et al. (2021), about 80% of scrubber discharges occur within 200 nautical miles of shore and there are spatial hot spots in heavily frequented regions such as the Mediterranean Sea. Considering territorial and inland waters, Italy ranks third worldwide, with a discharge value of 102 Mt and Greece ranks fourth, with 94 Mt. It is worth remembering that, as of 2021, some Med countries have established local restrictions to the discharge of wash water form open loop scrubbers in particular, Egypt has banned the discharge in all its ports and along the Suez Canal, Spain in the ports of Algeciras, Cartagena, or Huelva. The growing concern for the health of the marine environment and the possible establishment of Particular Sensitive Sea Areas (PSSAs) following IMO (2006) resolution will certainly lead to the prohibition of dumping scrubber residues at least in territorial waters and ports. It is thus expected that ports must have in the near future the capacity to handle scrubber waste residues by providing suitable reception facilities. According to data contained in the IMO Global Integrated Shipping Information System4 (GISIS), port reception facilities that can handle scrubber waste residues are located in Italy, Croatia, France, Morocco, Spain and Greece. Details regarding their capacity in m^3 and maximum discharge rate (m^3/h) are often not available. Anyhow, from available data it emerges that most of these facilities are small to medium-sized with a limited capacity at managing scrubber residues from large ships.

The forecast for future needs depends on a number of factors including the ship segment, the type of engine installed and the consumption of vessels equipped with scrubbers. In addition, there are a number of variables that are difficult to predict also in the short term, such as the price of low-Sulphur fuel or the fuel shift to LNG. An estimation can be made by considering an important class of ships for the Mediterranean, namely cruise ships. Although at global level discharge at sea from cruise ships represents 15% of the total wash water discharge only (Osipova et al. 2021), about 30% of cruise ships that spent at least 10% of their time sailing in the Mediterranean are equipped with scrubbers moreover, they sail for a significant part of their trip close to the coast and spend on average 25% of their time in port. It is worth mentioning that the most polluted Med port, when it comes to wash waters from scrubbers, is Civitavecchia (Osipova et al. 2021), a major call for cruise ships which, in addition, has not a scrubber waste reception facility. From the same sources it is possible to observe that 73% of the scrubber wash water discharged in the port of Civitavecchia and 75% of that discharged in the port of Barcelona comes from cruise ships. For these reasons it is realistic to assume that this class of ship will be the most affected by future regulations regarding water discharge into the Mediterranean.

Main assumptions of the study are: i) cruise ship services will reach the pre-Covid crisis *i.e.* 4400 per year, ii) the share of cruise ships equipped with scrubbers will increase up to 50% and iii) only ships that spend at least 7 days are considered, according to 2019 data, the corresponding percentage is 60%.

Moreover, considering data relative to the average consumption of cruise vessels (Merta et al. 2016), it is possible to assume that 832 m^3 of wash water will be generated in one week of navigation. With these figures, the potential market value for ECGS reception facilities in the Mediterranean consists of 1320 cruise services a year. Thus, a

potential of 1,1 million m^3 scrubbers wash water reception needs in the Mediterranean from cruise operations. Even if PSSAs may be increasing in the future, vessels are likely to discharge also wash waters in more distant, open, international waters rather than in national and along coastline waters. The proportion of ships that may find attractive to discharge in port facilities is therefore 80% of total wash waters discharge, since the remaining 20% could be unloaded in the open sea. The remaining demand can be met by four-five large size facilities in the Mediterranean, with a handling capacity of 500-700 tons of residuals and that can reach a rate of 100-120 m^3/h. A ship berthed for 7-8 hours, as it can be the case for cruise ships, could be fully unloaded by such a facility. The estimated capacity of these facilities considers an average operational time of 200 days per year. This conservative estimation can account also for the needs of other ship categories, such as containers' vessels, Ro-Ro and tankers.

4.3. Cultural Heritage Preservation

Cultural heritage assets such as historical buildings, archeological sites, and monuments, is subjected to continuous interactions with the surrounding environment, and thus to weathering processes which lead to its degradation change. These changes can derive both from natural effects and human activities. Considering specifically air pollution, major anthropic sources are industries, vehicular traffic, heating, and ship emissions along coastal areas.

Rainwater mainly contributes to degrade monuments. In terms of surface recession (i.e. stone material loss) degradation occurs through three different processes: *i)* a clean rain effect due to rain at pH ~ 5.6 in equilibrium with atmospheric CO_2, *ii*) an acid rain effect, caused by rain with additional acidity due to the presence of sulfuric and nitric acid, and *iii*) the dry deposition of gaseous pollutants, especially SO_2 and NO_x, occurring between precipitation events (Gómez-Bolea et al. 2012). Another important damage effect is the blackening and black crust formation which is mainly related to the high level of particulate concentration PM_{10} or $PM_{2.5}$.

Results of the POSEIDON Interreg-MED Project which monitored ship emission in four port-cities, Brindisi and Venice (Italy), Patras (Greece) and Rijeka (Croatia), showed that road traffic and shipping have comparable emissions in terms of NO_X and $PM_{2.5}$, whereas shipping is the main responsible for SO_2 emissions. It is therefore clear that the significant reduction of pollutant concentrations resulting from the creation of the Med SECA would generate a decrease of both erosion and blackening on historical buildings and monuments. A quantification of the reduction of these effects can be in principle done using available mathematical models developed on the basis of experimental evidence (Gómez-Bolea et al. 2012, Bonazza et al. 2021). However, the estimation requires the availability of accurate data on the concentration of each pollutants at different sites. Over the past 15-20 years, numerous air quality measurements have been carried out in ports and coastal cities as part of European, national and regional projects, providing a valuable database for this type of analysis. Based on the availability and completeness of these data, test cases will be selected, most likely in Italy, to deepen the study.

The benefit of preserving cultural heritage goes beyond an economic value however, in Italy was estimated that each monument, due to the combined effects of climate conditions and pollution, is restored on average every 25-30 years and that a rough evaluation of the cost is €1500/m^2. Moreover, considering that cultural tourism is estimated to be (world average) about 35% of the total tourism, the indirect economic benefit of SECA and possibly of NECA on cultural tourism could be very significant in the Mediterranean area where, according to the World Trade Organization, cultural tourism is a non-negligible part of the GDP and is expected to increase in the future.

5. Conclusions

This paper presented the objectives of the LIFE4MEDECA project and the methodology adopted to achieve them. In-depth analysis of relevant policy and economic documents, regulations, available technical reports and scientific publications, as well as information gathering carried out through networking with other projects and initiatives and input provided by involved stakeholders, led to the identification of critical issues to be addressed and gaps to be filled. Among these, during the first year of the project the attention has been focused on: a) the impact of LSFO in case of a spill at sea, b) the capacity of Mediterranean ports to handle vessels equipped with scrubbers and c) the benefits of reducing sulfur deposition on historic buildings with possible indirect effects on tourism.

Preliminary results of the studies indicate the need to *i)* test and validate the effectiveness of remediation strategies available in case of VLSFO/ULSFO spills and consider revising some regulations regarding their characteristics, *ii)*

build new large port reception facilities for the storage and treatment of residual water from ship scrubbers and *iii*) quantify benefits derived from the drastic reduction of SO_x and particulate matter on historic buildings.

Given the very limited amount of information and data on these issues, the studies performed are qualitative although some rough quantitative estimates have been provided. Future work will be devoted to a deeper analysis of the above topics also from an economic perspective, if relevant, and to the analysis of other relevant issues that can be related to SECA but also to NECA such as for instance the correlation between coastal acidification and eutrophication and ship emissions to quantify the environmental and economic benefits of Med SO_x ECA.

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