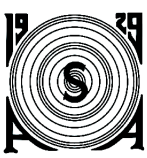

euronoise

The Port of Livorno noise mapping experience

Mario Morretta[a], Andrea Iacoponi[b] and Fabrizio Dolinich[a]

[a]Sintesis - Enginering and Consulting S.r.l., via Martin Luther King, 15, 57128 Livorno, Italy
[b]ARPAT - Dipartimento di Livorno, via Marradi, 114, 57128 Livorno, Italy
mario.morretta@sintesis.toscana.it

Livorno Municipality and its seaport are requested to produce the strategic noise map according to the European Directive only in 2012. However Livorno Port Authority, following the principle of environmental sustainability and in coherence with its EMAS status, started the investigation about the interaction between the noise generated by port activities and the nearby city.
This analysis has been carried out within the Life funded project NoMEPorts, whose goal is to develop and provide tools and expertise to European ports for implementing their strategic noise maps, by means of a collaborative mapping of 8 Port Authority technical representatives from all around Europe.
The presented work outlines in detail the process followed in performing the noise mapping of Livorno port area and the port-city interface area, focusing in the problems encountered in the data collection, in port noise model building steps and in the consequent solutions adopted. The paper also refers to the result obtained by showing the noise maps in six detail levels and reports about the action plan proposed.
As a result this experience emphasises the importance of noise maps as a powerful tool for decision-makers within port planning activity.

1 Introduction

In June 2002, the European Directive on the Assessment and Management of Environmental Noise 2002/49/EC [1], (further indicated by its abbreviation END) was accepted and came into force. Under this Directive, member states are obliged to produce strategic noise maps of major roads, railways, airports and large agglomerations. These noise maps shall express the environmental noise levels caused by the above sources, in terms of the harmonised noise indicators L_{den} and L_{night}. From these, other statistics such as the total number of residents exposed to certain noise levels shall be derived. This information shall then be submitted to the European Commission and made public. The next step will be to draft Noise Action Plans.

Noise mapping for agglomerations has to consider traffic on roads, railways, and airports as well as industrial activities including noise from port areas.

Although port area noise mapping should be though inside a greater mapping task, usually performed by local Municipality, it is generally advisable to deal port noise separately, leading to a simpler and more coherent view of the mapping task.

Timescale for implementation of port noise mapping sees June 2007 for agglomeration bigger that 250 thousands inhabitants and June 2012 (and therefore every 5 years) for agglomeration with 100 thousands inhabitants or more. Livorno agglomeration counts about 150 thousands inhabitants and therefore noise mapping of its territory is not due for the first round.

However, in order to give response to the increasing environmental sensitivity of the city and port users communities, Livorno Port Authority (LPA) has adopted an environmental management system (EMS) awarded, first in Europe in the port field, by the EMAS registration. The EMS has been developed as a platform of economic and environmental data and it is used as a management and decisional support tool.

In order to investigate the problem of port noise and its interaction with the surrounding city centre, LPA has been part of two pilot project: SIMPYC [2], devoted to study environmental aspects of the port-city interface and NoMEPorts [3], specifically dedicated to noise mapping of port area according with the END.

2 The NoMEPorts experience

The NoMEPorts (acronym of Noise Management in European Ports) project was conceived to provide a concrete methodology and relative tools in order to assess and, consequently, mitigate the noise annoyance generated by port activities. The project, promoted by the Port of Amsterdam was founded by Life Environment commission.

The END approach to noise management focuses not only on the environmental noise but also on the contribution of the various noise sources. By this vision, the project had as main goal to respond to the Port Authorities need of noise management through a rather innovative methodology for port field: noise modeling, port noise maps analysis, critical points identification and noise mitigation. In addition, this process has been developed to be consistent with an EMS by which a Port Authority could manage the coexistence between port activities and the neighbourhoods. This last step is not required by END, but gives the Port Authorities a fine tool to predict the effects of future developments in and around the port. It also provides the Port Specialists with the possibility to manage the layout of the port area, taking noise into account.

The first technical challenge introduced by the project and carried out by the partner port authorities has been the creation of a noise model of the port. By the support of noise experts, each port authority has developed their own model by a specific multipurpose software (Brüel & Kjær's Predictor™, ver. 5.15). This task has been faced preliminarily by a noise data collection campaign which involved not only port authorities but all the port tenants.

Following the noise maps analysis, a specific task about a first action plan development for port area has been developed.

In order to test this methodology on different port structures and different legislations, the project has been actively been participated by six European Port Authorities: Amsterdam, Copenhagen-Malmö, Civitavecchia, Hamburg, Livorno and Valencia. In addition to the full partners, other Port Authorities gave their availability to participate as observers: Bremen, Oslo, Rotterdam and Tenerife. Sintesis-Engineering & Consulting S.r.l. and ARPAT-Department of Livorno have been supported LPA for all the technical issues regarding the project.

All the results coming from the partners were analysed and condensed in a "good practice guide" for port area noise mapping, one of the principal outcomes of the NoMEPorts project.

3 Mapping area overview

In the first step of the project a collection of basic data was carried out in order to deepen the knowledge about the area under study, the noise sources and receptors of interest. The analysis showed how complex the acoustic situation is. This is mainly due to the vicinity of the port area to the urban context and to the presence of a lot of noise sources.

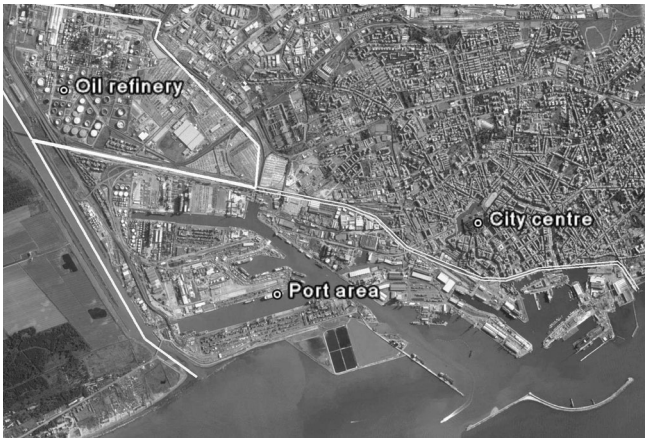

Fig.1. Contiguity between the city and the port of Livorno (the double line represents the port-city interface).

With 2.5 million square meters of surface, Livorno port is devoted to both commercial and tourist traffic; it counts over 90 berths along 11 km of docks. During 2007 almost 33 million tons of goods were handled either by container (with more than 700 thousands TEUs) or as bulk goods. In the same year 2.2 millions passengers were landed by ferries, plus 700 thousands passengers by cruise ships; as a consequence, 7.628 ships berthed with a total gross tonnage of almost 158 millions tons. The passenger station is one of the nearest port activities to the city centre.

Due the contiguity between port and city, all the activities carried out in the port contribute to the acoustic level of the nearest urban receptors (e.g. dwellings). One of the main noise source of interest is the road network to access the port. This network mainly runs along the port-city interface and is shared by the heavy commercial traffic, due to the port activities, and the light traffic entering and leaving the city. Not less relevant is the presence of a dedicated railway line which connect the port to the railway network.

Inside the port area there is also an industrial district, which benefits of the port connections and therefore gives a remarkable contribution to the terrestrial traffic. Finally, berthed ships should also be accounted, also because of their close distance to the residential area.

No one of the noise studies previously carried out before the NoMEPorts project give any information about the specific contribution of the various sources to the acoustic climate. In consequence, one of the first goals set for the study was to develop noise maps depicting the single contribution of the main sources. The noise sources were grouped in 5 items to be evaluated: road traffic, railroad traffic, container and bulk terminals, industries, berthed ships.

4 Data collection and modelling

Port noise, taken as a whole, has an original connotation respect to the other noise sources usually considered such as roads, railroads, industries, airports, etc. This particularity is mainly due to noise generated from large ships berthed and operations of goods loading and unloading. Noise modelling represents therefore a real challenge; a port is indeed a city within a city, and shows all the difficulties due to the presence of many kind of sources that also overlaps with a urban context.

The availability of a good digital cartography represents the starting point for the implementation of the mapping plan. In this study a digital 3D cartography of Livorno area was used. This electronic map, available at a very high detail level, was very valuable for creating a three-dimensional model of the area under study. In order to develop an accurate propagation model, along the natural orography and anthropic obstacles (e.g. dwellings, city walls, etc.) much attention has been paid to other elements affecting the noise propagation that are not highlighted on official maps as containers stacks; in terms of acoustic propagation, they act as sound barriers of considerable height (around 8-10 meters). Considering their variability in height, an assessment of the average height of stacked containers was carried out.

The 3D area modelling was followed by the introduction of the most significant noise sources in the software. The sources were modelled by the definition of: the feature (point, line or area objects), the location on the map, the annual average activation duration (within the three daily bands Day, Evening and Night, accordingly to the END), and the emission spectrum.

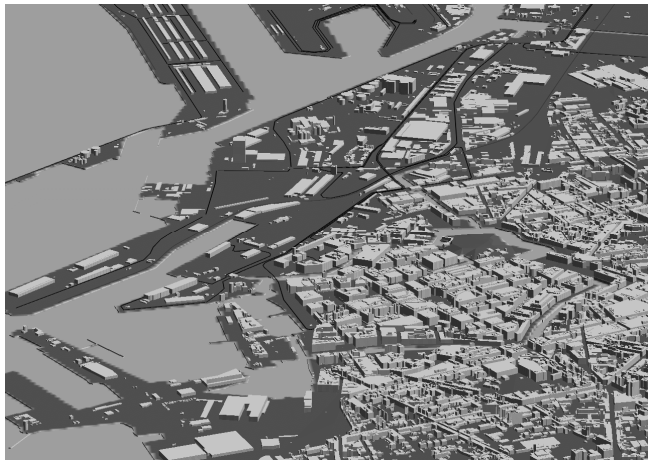

Fig.2. Three-dimensional model of Livorno and its port.

As the various noise sources are very different to each other two distinct modelling approach were used: analytical and "by measure".

In the first case each representative sources has been analytically characterised. The information needed by the model have been obtained using operational data provided by managers of the handling terminal: percentage of work shifts activation time, average execution time of single operations, percentage of rail transport, number of vessels and their time of dock permanence. Emission spectra of the various source types were modelled using the IMAGINE European project [4] source database. The second approach

was applied in order to model certain areas for which an analytical approach was not allowed, mainly due to a lack of operational data (e.g. industry district). In this case, the area has been modelled as an area object and the model calibrated by experimental data collected around the area of interest or, when available, using noise impact assessment performed by industries inside port boundary.

Among the noise sources due to port activities, the road traffic is a significant component. This is because most of the vehicles used in this area are trucks, whose noise emission is significantly higher than the one produced by cars or motorcycles. Port of Livorno has a constant inbound and outbound traffic of heavy vehicles which determines a significant noise impact coming from the road communication network and port internal roads. The noise emitted by this traffic has been evaluated in terms of number of trucks crossing the port thanks to data collected by Port Authority. Goods handling short trips within container handling areas were took into account. They generate a significant heavy vehicles traffic (trucks and shuttles) taking part to the chain of import/export operations. At this local traffic the one determined by fork-lift and reach-stackers was added.

Light traffic has not been included in the model calculation because it was not considered as significant compared with heavy traffic.

The railways traffic data collection has been acquired by the local railway operator and compared to those declared by the port terminal operators. The modelling of this source required some approximations because of the lack of knowledge about the technical specifications of railway wagon used and the average speed of the convoys.

Finally, the ships were taken into account as noise source as well. Their contribution to port noise is mainly due to the use of internal combustion engines which run when approaching or leaving docks and supply energy when berthed. In order to simplify the model, the noise emitted by manoeuvring ships were not considered. This is according with the consideration that on long observation periods, the manoeuvring period is negligible compared to the berthing period.

The data about the kind of vessel, its tonnage, the approaching and leaving time, the mooring location was provided by the Port Authority in a non-aggregate form. Thanks to the availability of detailed data the classification for tonnage classes and permanence time (within the three daily bands day, evening and night, accordingly to the END) has been possible.

Great distances between sources and receivers made necessary to perform an analysis of meteorological conditions relevant for noise propagation. This was done using freely available meteorological data following the IMAGINE project outcome [5].

All the data collected were used to feed the spatial model, developed under the work environment made available by Predictor^{TM}. This software includes an acoustic determinator offering a wide choice of noise propagation models, including the END *ad interim* models (XPS 31-133 for roads, ISO 9613 for industrial noise, etc) and the forthcoming HARMONOISE-IMAGINE general purpose European model. The last one was used for the pourposes of the NoMEPorts project.

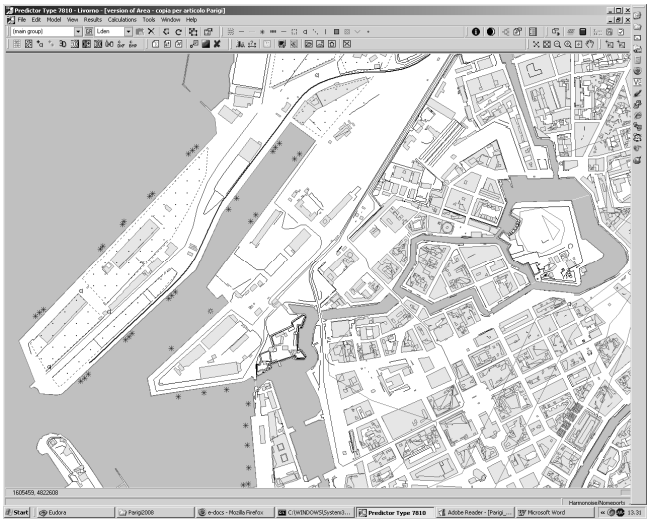

Fig.3. Detail of modelling stage.

5 Results

The model was calibrated by a trial-and-error process where each run was performed in order to highlight – and therefore correct – various aspect of the model itself.

Once a stable version of the model was finally obtained, the software was run to develop various noise maps and then to perform an analysis of noise emission and the related impact on dwellings surrounding the port.

One of the most valuable advantage in using a prediction software is the ability to produce different scenarios by varying the model parameters, completing the mapping of a rather large area in a reasonable time (about 2 days to calculate a grid of points above 2 square kilometres). This methodology also permits to easily analyse the contribution of different classes of noise sources. This deep investigation let the analyst to individuate the most annoying sources. Furthermore, the knowledge of the weight of the various sources permits to individuate noise mitigation measure tailored on specific sources, obtaining actions more reliable and effective.

A graphical representation of the run with all sources active is depicted in fig. 4, where noise levels are expressed in terms of the European noise indicator L_{den}. By the comparison of the maps developed for each one of the group sources, the road traffic of heavy vehicles was recognized as one of the main cause of noise pollution with respects of urban residential area. In terms of absolute noise emission, the industrial area seems to predominate; however, the great distance from the urban area permits noise to decrease to negligible levels. Berthed ships represent another significant noise source; a rather noteworthy contribution has given by ferries and cruise vessels even because of the proximity of the passenger station to the city centre.

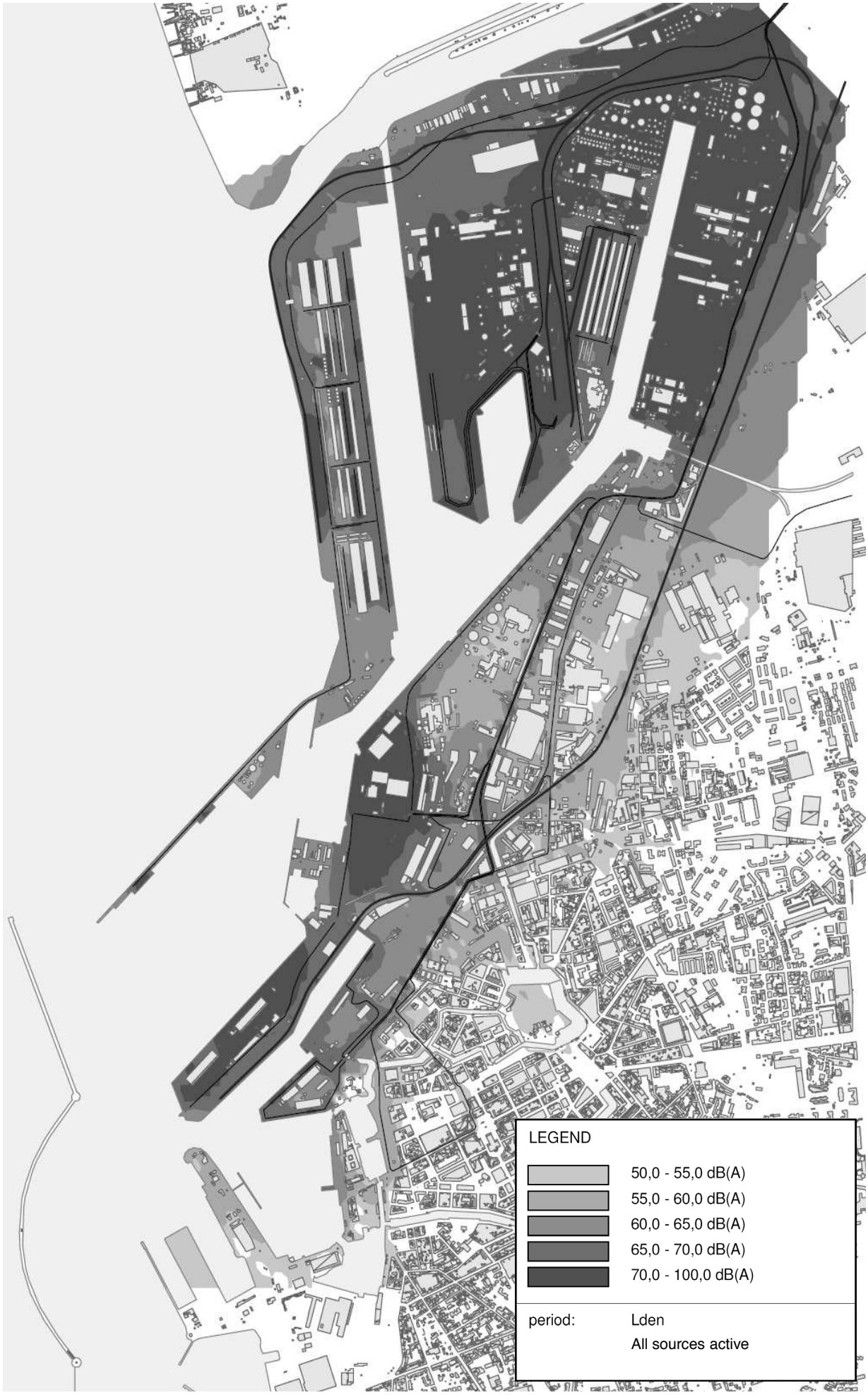

Fig.4. Port of Livorno noise mapping: overall L_{den} levels at 4 metes height.

A separate analysis has been performed in order to estimate the population exposed to port noise. This task has been carried out on the base of census information, providing the number of inhabitants per building, and the L_{den} levels at 4 meters height. Cross-correlation of those information permitted to infer the number of exposed people. It can be shown that, for the particular case of Livorno, port noise impacts marginally the city, resulting in a low index of exposed population (see fig. 5).

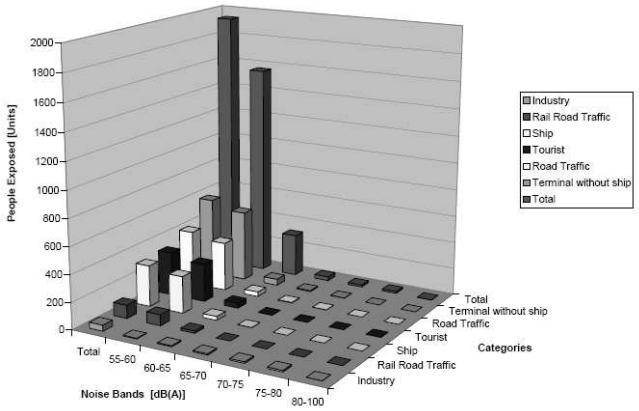

Fig.5. Estimation of people exposed to various L_{den} levels.

The Italian legislation has not yet defined a L_{den} limit or quality value, so it's difficult to recognize how many people are exposed to an L_{den} value greater then the reference. However, taking into account that the current daytime limit value for the "mixed areas (industrial and residential)" is 60 dB(A) (equivalent level calculated between 6.00-22.00 h), the total number of people exposed to an environmental noise greater than this value can be estimated in about 300 inhabitants. Nightly period highlights a more critical situation, also because terminal and industry activity runs 24 hours a day; taking into account 50 dB(A) as reasonable nightly limit value, the total number of people exposed to a greater value was estimated in about 900 inhabitants.

Even if the noise situation does not seems to be so worrying, Livorno Port Authority designed and implemented some mitigating measures in order to best improve the general acoustic situation. The solutions found have not be designed exclusively to reduce noise annoyance, but aim to improve several environmental aspects (e.g. fugitive emission, noise, traffic congestion, etc.) leading to influence positively the general situation.

Both solutions base their effectiveness in locating noise activities more distant from receptor's area; the first measure consists in developing a new access to the tourist terminal area. As a consequence, all passenger traffic does not mix up anymore with the urban traffic with a significant reduction in noise levels, expected around 5÷6 dB(A) during summer season, but also leading to a general liveability improvement of the urban area.

The second, the most ambitious measure, consists in relocating the bulk terminal. The analysis carried out highlighted that the current position affects negatively the surrounding dwellings, specially those located on the waterfront. In addition, this area is often affected by airborne dust, diffused by wind from the solid bulk terminal facing this highly populated area. In order to put away the solid bulk terminal from the city, the Port Authority planned to build up a new wharf where the bulk terminal will keep on carrying out its activity. The area left free may be used to host part of the tourist activities, moving them away from the city and producing a further improvement of the acoustic aspects.

6 Conclusions

Following the choice of the environmental sustainability politics, also enforced by an EMS complying the EMAS registration, Livorno Port Authority used a prediction systems to perform a strategic mapping of the noise produced by the activities of its port, according to the indication of the END directive. The task was carried out within the NoMEPorts project.

Although ports are not indicated by the directive as main actors in noise mapping, but are considered as part of major agglomeration, NoMEPorts experience showed that, from a modelling point of view, a port behaves like a "city within a city" deserving to be dealt separately from the rest of the agglomerates.

Noise mapping and the availability of prediction system has demonstrated to be a valuable instrument not only to highlight the problems related to noise pollution but also to help in managing mitigation actions in a more effective and reliable way. Furthermore, the developed noise model of the port could be used also as a decision support tool within the prediction of the noise impact due to different port growth scenarios.

References

[1] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, Official Journal of the European Communities L 189 dated 18/7/2002.

[2] SYMPIC website: http://www.simpyc.info .

[3] NoMEPorts website: http://nomeports.ecoports.com .

[4] IMAGINE website: http://www.imagine-project.org .

[5] A.Iacoponi, F.Dolinich, "La determinazione dell'anno medio meteorologico nella valutazione dell'indicatore europeo L_{den}" – *Atti del 34° Convegno Nazionale dell'Associazione Italiana di Acustica* (Firenze, 13-15 giugno 2007)

[6] M.Morretta, F.Dolinich, A.Iacoponi, "Risultati della realizzazione di un modello acustico del Porto di Livorno realizzato nell'ambito del progetto NoMEPorts", *La Gazzetta Marittima*, gennaio 2008, pag.43-48.