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Advanced Noise Control strategies in HarbOuR

State of the art of best practices for port noise management

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Content

1. Executive Summary

The ANCHOR LIFE report on the state of the art of best practices for port noise management deals with the identification and evaluation of the noise contribution sources normally present in a harbour. The Technical regulations on port noise, as well as the European and National (Greek, Italian and Spanish) ones are described. Besides, an overview of the EU projects on port noise and port noise measurement campaigns is implemented.

2. Introduction

Currently there are no specific regulations for the protection of the population exposed to noise emitted by harbour infrastructures, neither with regards to the national legislations of the project partners, nor in the area of regulations issued by the European Union. In general, noise pollution at harbour areas has only been partially addressed, considering the harbours themselves as a single source of noise, similar to an industrial area. Even if different activities are attributable to those typical of manufacturing settlements, harbours are characterised by different types of sound sources. Therefore, it is important to start with the identification and evaluation of the noise contribution sources normally present in a harbour. This step is useful for having a clearer approach in applying the current legislation on noise pollution to harbour areas. Since the problem of noise in harbours is generally due to noise emissions radiated by ships, in this report the attention will be mainly focused on the noise generated by various types of vessels, also because the noise due to other types of sources is strictly linked to the presence of the ships themselves in the harbour. Inside a harbour area, we can distinguish noise pollution due to ships in two types:

- *direct* noise;
- *indirect* noise.

By *direct* noise we mean the noise produced from the ships engines in two operating conditions:

- when the ship is in underway during the maneuvering phase inside the harbour (approach phase to the dock and removal phase from the dock);
- when the ship is not moving and moored to the dock.

In the first case, the ship can be considered a moving type source, while in the second case as a fixed source, with a steady-state emission over time. It should be pointed out that, since the maneuvering times are significantly lower than those of mooring, the first contribution can generally be neglected in the evaluation context of the acoustic impact.

By *indirect* noise we mean the noise associated with the various activities that take place at the harbour when a ship is present:

- goods handling and loading / unloading;
- shipyards;
- road and rail traffic to and from the harbour.

In noise assessment, both direct and indirect, it is also important to consider the type of ship under investigation: container ships, oil tankers, ferries, cruise ships, tugs, general cargo ships, fishing boats, recreational vessels, etc. For example, ferries, general cargo ships and container ships, typically spend long periods of time moored to the dock with auxiliary engines in operation, therefore, both direct and indirect noise should be considered. For other categories of ships, direct noise is generally not considered, as the auxiliary systems usually remain out of service while the ship is moored. Considering, instead, the cases related to cruise ships and cargo ships (general cargo and containers), both create very consistent indirect noise due to handling activities carried out on the dock, while the contribution of direct noise generated by cruise ships is negligible due to the high soundproofing of the structures.

3. Technical regulation on port noise

At present, within the sector technical legislation, four international standards for environmental noise assessment are available, each of which is applicable to specific types of boats.

The ISO 2922: 2000 standard "Measurement of airborne noise emitted by vessels on inland waterways and harbours" establishes the conditions for obtaining reproducible and comparable measurements of the sound level and the noise spectrum generated by all types of ships on inland and harbour navigation with the exception of motorised recreational motor boats, as specified in the ISO 14509 standard. The standard can also be applied to small sea-going vessels, port vessels and dredgers. The standard distinguishes two different test modes: for ships in the navigation phase and moored to the dock. For the navigation phase, two acoustic indicators were chosen: the sound level at a single event, L_{AE} (SEL - Sound Exposure Level) and the maximum A-weighted sound pressure level, L_{ASmax} (Slow time weighting). For the moored ship the continuous equivalent A-weighted sound pressure level L_{Aeq} (Fast time weighting) was chosen as the acoustic indicator. The instrumental surveys must be carried out under certain environmental and operating conditions of the boats. The modalities for the measurement of residual noise are also expected.

For the navigation phase, the measurement methodology involves surveying with at least two ship transfers. The measurement time should include the periods during which the noise level emitted by the ship during the transfer is higher than 10 dB compared to those of other sources. In the case of moored boats, the expected measurement time must not be less than 30 s.
The ISO 14509 standard series has its field of application the powered pleasure boats with lengths up to 24 m and which require that the measurements for the test and monitoring tests are carried out only in the condition of a moving boat.

The ISO 14509-1: 2009 standard "Small craft - Airborne sound emitted by powered recreational craft - Part 1: Pass-by measurement procedures" specifies the conditions for obtaining reproducible and comparable measurements of the maximum sound pressure level of airborne noise generated during the transfer of powered recreational boats with the hull lengths up to 24 m, including those with inboard engines, with stern drive, private jet skis and those with outboard engines. It also defines the procedures to be adopted for the measurement of acoustic indicators L'_{ASmax} (A-weighted maximum sound pressure level with Slow time weighting during the transfer) and L_{ASmax} (L'_{ASmax} with correction for background noise and for the distance).

The ISO 14509-2: 2008 standard "Small craft - Airborne sound emitted by powered recreational craft - Part 2: Sound assessment using reference craft" specifies the methods to evaluate the sound emission of single-hull motor boats from recreational crafts, up to 24 m long, and is not applicable for testing outboard engines and stern drive engines with integrated exhaust systems.

The ISO 14509-3: 2009 "Small craft -- Airborne sound emitted by powered recreational craft – Part 3: Sound assessment using calculation and measurement procedures" specifies the procedures for evaluating the A-weighted sound pressure level for recreational boats, motorboats and boats up to 24 m in length with a Froude number higher than 1.1.

4. European regulation on noise pollution

The Directive 2002/49/EC relating to the determination and management of environmental noise (END - Environmental Noise Directive) aims to define a common approach for the European Union in order to avoid, prevent or reduce the harmful effects caused by exposure to environmental noise. The Directive applies to the surroundings to which the population is generally exposed to, in particular in built-up areas, in public parks or other quiet areas of urban agglomeration, in quiet areas in the open countryside, near schools, hospitals and other particular buildings and areas sensitive to noise. However, the noise caused by exposed persons, such as the noise of domestic activities, workplaces, within means of transport or in military areas, is excluded from the scope of the END.

To ensure a high level of environmental protection and to safeguard people's health, the directive proposes a community action aimed at achieving a common awareness of the problem made up of noise. Data on environmental noise levels must therefore be collected, sorted and presented according to common criteria. This implies the use of consistent indicators and assessment methods, as well as consistent criteria for noise mapping carried out by member states.

The planned acoustic descriptors of the directive in its annex I are the following:

- L_{den}: A-weighted sound pressure level, relative to the day-evening-night periods;
- L_{night}: A-weighted sound pressure level referred to the night period.

These indicators have been formulated to correlate the measurement of sound pressure level and the percentage of people who have negative effects on health, due to prolonged exposure to the source of noise above described. The correlation between the harmful effect and the acoustic signal is made not directly through the noise levels, but rather by the dose-effect relationship. The directive considers two harmful effects: discomfort and sleep disorders. In order to obtain a high correlation coefficient of the dose-effect relationship, several studies have addressed the formulation of an appropriate acoustic indicator: the best results have been obtained precisely with L_{den} and L_{night}, respectively for discomfort and sleep disorders. The possibility is also provided for member states to use additional indicators in order to monitor or control specific situations of noise impact.

The L_{den} level, expressed in dB (A), is defined by the following formula:

$$L_{den} = 10 \log \frac{1}{24}\left(12 \cdot 10^{\frac{L_{day}}{10}} + 4 \cdot 10^{\frac{L_{evening}+5}{10}} + 8 \cdot 10^{\frac{L_{night}+10}{10}}\right)$$

where L_{day}, $L_{evening}$ and L_{night} are the A-weighted long-term average sound pressure levels, defined in the **ISO 1996-2: 1987 standard**, determined on the whole of the one, respectively day, evening and night periods. The one-year observation period is significant both in terms of noise emissions and meteorological trend. Usually the day period is 12 hours, the evening 4 hours and the night 8 hours, as specified below:

- day: 7.00 am-7.00 pm;
- evening: 19.00-23.00;
- night: 11.00-7.00

although the different member states have the right to define different time intervals and durations for the three periods.

The Directive considers noise levels as an incident sound, without taking into account the sound reflected from the façade of buildings. In general, this implies a correction of 3 dB (A) in measurements or provisional calculations made at a distance of about 1 m from the façade of buildings. In relation to the height where sound levels are to be assessed, in the case of acoustic mappings, a height of 4 m ± 0.2 m (3.8 ÷ 4.2 m) from the ground and in correspondence with the most exposed façade must be considered.

Regarding noise due to harbour activities, Annex IV of the Directive provides the preparation of strategic noise maps for urban areas: for this reason, ports are classified as industrial sources. It is therefore possible to apply the L_{den} and L_{night} acoustic indicators also for sound sources that characterise the acoustic emissions of harbours, if these are in the areas considered such as agglomeration. A correct approach to the description of harbour noise, therefore, requires an analysis of the different sources that determine the overall noise emitted by the source harbour, through the use of acoustic indicators already in use for mappings.

Currently, no limit values have been established for boats while sailing at sea. In the case of navigation in inland waters, there are limits referred to in Article 8.10 of Directive 2006/87 / EC:

- for ships at sea, 75 dB (A) at a distance of 25 m from the ship;
- for moored ships 65 dB (A) at a distance of 25 m from the ship, with the exclusion of loading / unloading operations.

With regard to noise emissions in the navigation phase, reference is made to the noise produced by the engines coming from the intake and exhaust holes.

It is important to recall the Commission's recommendation of 8 May 2006 aimed at promoting the use of electricity supplied by land-based electricity networks (so-called cold ironing) for ships moored in community ports, located near residential areas where:

1. the limit values for air quality are exceeded;

2. fears have been expressed regarding high levels of noise pollution.

The electrification of the docks, if on one side would allow the switching off of the auxiliary engines during the mooring phase, on the other hand has found little application due to the reluctance of the owners in equipping the ships with the necessary systems of electrical connection to the quay.

5. National regulations on acoustic pollution

5.1 *Italy*

The law n. 447 of 26 October 1995 "*Framework law on noise pollution*" defines the competences of public bodies in charge of regulatory and control activities, as well as the commitments to which individuals are responsible for acoustic emissions.

The general nature of the law can be deduced from the way it defines "noise pollution", which means: "*The introduction of noise into the living environment or into the external environment such as to cause discomfort or disturbance to rest and human activities, danger to human health, deterioration of the ecosystem, material goods, monuments, living environment or external environment such as to interfere with the legitimate use of the same environments* "(art. 2, paragraph 1, letter a).

A series of implementing decrees and regional laws descend from to this law, which defines the "*Reference framework*". The sector legislation concerning the subject is mainly represented by the one reported below:

- *D.P.C.M. November 14, 1997 "Determination of the limit values of sound sources*";
- D. M. 16 March 1998 "*Techniques of detection and measurement of noise pollution*";
- D. M. 11/29/2000 "*Criteria for provisions of plans by companies and managing bodies of public transport services or related infrastructures to contain and reduce noise*";
- Presidential Decree March 30, 2004, n. 142 "*Provisions for the containment and prevention of noise pollution deriving from vehicular traffic, according to Article 11 of Law 26 October 1995, n. 447* ";
- Presidential Decree November 18, 1998, n. 459 "*Regulation containing rules for the execution of article 11 of the law of 26 October 1995, n. 447, concerning noise pollution deriving from railway traffic*".

The Framework Law establishes, among other things, the fundamental principles regarding the protection of the external environment and the living environment from noise pollution by identifying as the main instrument the "*acoustic zoning*" of the municipal territory, that is the identification, depending on the intended use of acoustically homogeneous areas, to each of which a noise limit value is assigned. For these acoustic classes the D.P.C.M. 11/14/1997 specifies the emission limit values of individual sources, the input values of the external environment produced by all of sources present in the area under examination, the alert values and the quality values. Table 5.1, Table 5.2, Table 5.3 and Table 5.4 show the qualitative descriptions of the acoustic classes and the limit values defined by current legislation.

Table 5.1 - Definition of the acoustic zoning classes of the territory

CLASS I - Particularly protected areas This area includes areas where silence represents a basic element for their use: hospital areas, schools, areas for rest and leisure, rural residential areas, areas of particular urban interest, public parks, etc.
CLASS II - Areas intended for predominantly residential use This class includes urban areas mainly affected by local vehicular traffic, with low population density, with limited presence of commercial activities and the absence of industrial and craftsmanship activities.
CLASS III - Mixed type areas This class includes urban areas affected by local vehicular traffic and crossing, with an average population density with commercial activities, offices, with limited presence of craftsmanship activities and with no industrial activities; rural areas affected by activities that use operating machines.
CLASS IV - Areas of intense human activity This class includes urban areas affected by intense vehicular traffic, with a high population density, with a high presence of commercial activities and offices, with craftsmanship activities; areas close to major roads and railway lines; harbour areas; areas with limited presence of small industries.
CLASS V - Mainly industrial areas This class includes areas affected by industrial settlements and scarce housing.
CLASS VI - Exclusively industrial areas This area includes areas exclusively affected by industrial activities and without housing settlements.

Table 5.2 - Emission limit values - L_{eq} in dB (A)

Classes of destination use of the territory	Reference	
	***Daytime L_{Aeq}* (06.00-22.00)**	***Nightime L_{Aeq}* (22.00-06.00)**
I - Particularly protected areas	45	35
I - Predominantly residential areas	50	40
III - Mixed type areas	55	45
IV - Areas of intense human activity	60	50
V - Predominantly industrial areas	65	55
VI - Exclusively industrial areas	65	65

Table 5.3 - Absolute input limit values - L_{eq} in dB (A)

Classes of destination use of the territory	Reference	
	***Daytime L_{Aeq}* (06.00-22.00)**	***Nightime L_{Aeq}* (22.00-06.00)**
I - Particularly protected areas	50	40
I - Predominantly residential areas	55	45
III - Mixed type areas	60	50
IV - Areas of intense human activity	65	55
V - Predominantly industrial areas	70	60
VI - Exclusively industrial areas	70	70

Table 5.4 - Quality values - L_{eq} in dB (A)

Classes of destination use of the territory	Reference	
	***Daytime L_{Aeq}* (06.00-22.00)**	***Nightime L_{Aeq}* (22.00-06.00)**
I - Particularly protected areas	47	37
I - Predominantly residential areas	52	42
III - Mixed type areas	57	47
IV - Areas of intense human activity	62	52
V - Predominantly industrial areas	67	57
VI - Exclusively industrial areas	70	70

Furthermore, thanks to the emission of regulations provided by the Framework Law n. 447/1995, the national legislation on noise pollution has been completed over the years. It also concerns transport infrastructures (roads, railways and airports), which have regulated the methods of assessment and control of the acoustic impact.

The Framework Law, regarding harbour infrastructures and the noise emitted by boats, among the competences of the State provides for the issuing of two decrees, and in particular:

1) "*by decree of the Minister of the environment, in consultation with the Minister of Transport and Navigation, the determination of the criteria for measuring the noise emitted by vessels of any nature and the relative discipline for containing noise pollution*" (Article 3, paragraph 1, letter l);

2) *"(...) by decree of the President of the Republic, after deliberation by the Council of Ministers, on the proposal of the Minister of the Environment, according to the subjects of their respective competence, with the Ministers of Health, Industry, Commerce and of craftsmanship, transport and navigation, public works and defense, implementing regulations are issued, labeled sound source in relation to the noise pollution regulation originating from vehicular, railway, maritime and air traffic, also making use of contributions technical-scientific of the managing bodies of the aforesaid services, from the racetracks, from the test engine tracks and for sports activities, from boats, from boats of any nature, as well as from new airport locations.* " (art. 11, paragraph 1).

Although explicitly provided for by the Framework Law, harbour infrastructures have not yet been the subject of a specific regulation relating to noise pollution. The failure to issue implementing regulations for harbours represents a serious gap, as it involves technical and regulatory problems in assessing environmental impact due to sound sources present in the harbour infrastructures. Moreover, these problems also result in the impossibility of implementing effective measures aimed at reducing the noise introduced into the receptors in the areas facing the infrastructure itself. The implementation regulations, in fact, have defined at an instrumental level the methods of measurement and monitoring of the various sources, also providing specific acoustic descriptors, suitable for a more correct assessment of the impact produced on the environment. Furthermore, the legislation established the extension of appropriate bands or buffer areas of acoustic relevance, characterised internally by specific limit values of the infrastructures themselves, notwithstanding the municipal acoustic classifications.

The *D.M. 11/29/2000*, in fact, provides that the companies and bodies that manage public transport services or related infrastructures, including harbours, prepare plans to contain and reduce the noise produced during the operation of the infrastructures themselves. This obligation cannot currently be fulfilled by the parties responsible for harbour infrastructures precisely because of the lack of sector discipline.

Another important critical point is found in the *Environmental Impact Assessment (EIA)* procedures. Indeed, the Environmental Impact Studies of the works relating to the Noise component cannot be drafted on the basis of scientifically robust and reliable criteria. The main problems, currently not easy to solve, rely in the identification of suitable methods of measurement and evaluation of the noise emissions of the various sources, in the identification of the limit values applicable to the receptors and in the actual effectiveness of any acoustic retrofit.

The problems mentioned above are also supplemented by those relating to the acoustic mapping provided for by the European Directive on environmental noise *2002/49/EC*. In this context, the noise levels calculated using the L_{den} descriptor must be harmonised with the levels expressed in the acoustic descriptors provided for by the national legislation, which are currently not available for harbours. Furthermore, the Directive provides for the future elaboration of action plans, which must be based on the containment of sound levels below the limit values expressed in L_{den} (to be established at the level of member states) and which must also be harmonised with the provisions of the Noise Reduction and Containment Plans according to the *D.M. 29/11/2000*.

5.2 *Greece*

BUILDING REGULATION, Article 12 of the GFC (Government Gazette 59 / D / 3-2-89)

The purpose is to regulate the construction works as a whole and to their individual components in order to serve their intended use and under normal project maintenance conditions, for an economically acceptable service life, to meet the following requirements:

- Improve the comfort, health and safety of residents and residents.
- Improve the quality, safety, durability, aesthetics and functionality of buildings.
- The protection of the environment.
- Facilitating and promoting scientific research in the field of construction.
- Increasing productivity in building construction).

Joint Ministerial Decision 69269/1990

Classification of projects and activities in categories, content of Environmental Impact Assessment (EIA), definition of content of special environmental studies and other relevant provisions, in accordance with Law 1650/86.

LAW 4530/2018 (Government Gazette A 59 / 30.03.2018) Transport themes and other arrangements.

The provisions of this Directive shall apply to drivers who have entered into any agreement with the owners of the Passenger Public Use Vehicles (ESR) and the owners, who in person drive the ESCs cars.

5.3 *Spain*

Law 37/2003, of November 17, of Noise.

This law constitutes a partial transposition of Directive 2002/49/EC which, in addition, introduces the following points:

- the attribution of competences between the general administration of the state, autonomous communities and town halls;
- the sectorization of the territory in acoustic areas is introduced, depending on the predominant land use (residential, industrial, infrastructure, natural areas...). Acoustic areas quality objectives must be defined in a regulatory development;
- the possibility of establishing zones of acoustic easement associated with the infrastructures is introduced;
- includes a chapter on acoustic prevention where it is established:
    - the administrative intervention on acoustic emitters (actions that require environmental authorization, municipal license ...);
    - the possibility of establishing:
        - reservations of sounds of natural origin, endowed with special protection;
        - areas of special acoustic protection, where the quality objectives are breached and on which specific zonal plans must be prepared to improve the situation;
        - zones of special acoustic situation, where the zonal plans are not effective, proceeding to adopt long-term measures aimed at meeting the quality objectives corresponding to the interior spaces;
- a penalties and inspection regime is included.

Royal Decree 1513/2005, of December 16, by which Law 37/2003, of November 17, of Noise, is developed in relation to the evaluation and management of environmental noise.

This decree complements the noise law, based on the specifications indicated in Directive 2002/49/EC, in relation to noise indicators to be used and their evaluation. Likewise, the specifications and territorial scope of noise maps and action plans are complemented.

Royal Decree 1367/2007, of October 19, by which Law 37/2003, of November 17, of Noise, is developed in terms of acoustic zoning, quality objectives and acoustic emissions.

This Royal Decree develops the law of noise, specifying the following aspects:

- the quality objectives corresponding to the acoustic areas are established, in the interior living space and the quality objective relative to vibrations. In addition, the conditions for the delimitation of the acoustic areas are established;
- the procedure for the delimitation of acoustic easement areas is established;
- limit values for noise immission applicable to new infrastructures (road, rail, airport, port and activities) are established (Figure 5.1).

Tabla B1. Valores límite de inmisión de ruido aplicables a infraestructuras portuarias y a actividades.

Tipo de área acústica		Índices de ruido		
		$L_{K,d}$	$L_{K,e}$	$L_{K,n}$
e	Sectores del territorio con predominio de suelo de uso sanitario, docente y cultural que requiera una especial protección contra la contaminación acústica	50	50	40
a	Sectores del territorio con predominio de suelo de uso residencial.	55	55	45
d	Sectores del territorio con predominio de suelo de uso terciario distinto del contemplado en c.	60	60	50
c	Sectores del territorio con predominio de suelo de uso recreativo y de espectáculos.	63	63	53
b	Sectores del territorio con predominio de suelo de uso industrial	65	65	55

Figure 5.1 - Limit values for noise immission applicable to new infrastructures

Royal Decree 1038/2012, of July 6, which modifies Royal Decree 1367/2007, of October 19, by which Law 37/2003, of November 17, on noise, is developed in reference to acoustic zoning, quality objectives and acoustic emissions.

This Royal Decree includes a modification in the definition of the quality objectives corresponding to the sectors of the territory affected to general systems of transport infrastructures. In such cases it states that, in the perimeter boundary of these, not acoustic quality objectives for noise applicable to other acoustic areas surrounding them will be exceeded.

Royal Legislative Decree 2/2011, of September 5, approving the Consolidated Text of the Law of State Ports and the Merchant Navy.

Legislation of basic character relative to the ports of the state (dependent on the central administration), where the following content is mainly developed:

- organization and management of the port system;
- planning and construction regime;
- environment and security;
- public domain;
- provision of services;
- economic system.

6. European projects on the port noise and measurement campaigns

From the awareness of the problems of acoustic pollution and on the basis of the enactment of Directive 2002/49/EC, several European projects concerning harbour noise have been proposed and developed. Three of these European projects have addressed the acoustic problems relating to harbour and interconnection between the urban agglomeration and the harbour itself: the NoMePorts project (NOise Management in European Ports), the SIMPYC project and the SILENV project (Ships oriented Innovative soLutions to rEduce Noise and Vibrations).

The NoMePorts project (as part of ECOPORTS) was based on the concept of shared knowledge of problems related to noise, with the aim of creating a common working platform between European harbours in terms of implementing the environmental noise directive. The SIMPYC project was aimed at creating tools to share environmental policies between port authorities and municipalities affected by noise emissions, to reduce noise and atmospheric pollution. Finally, the SILENV project has contributed with important technical and managerial solutions for the characterisation and management of noise in the harbour area.

6.1 European projects

ECOPORTS

ECOPORTS [1] was established by 9 European Port Authorities as a platform for the exchange of experiences in the sectors for environment and sustainability in the harbour area. This has allowed the European Port Communities to exchange effective solutions for the environment and work together in collaborative projects on aspects of sustainability in ports and on the supply chain.

In order to provide a platform for the continuation of products and services developed through the ECOPORTS project and other European cooperation projects on sustainability in ports and the logistics chain in the future, the non-profit organization Ecoports Foundation (EPF) was established in 1999. This Foundation has played an important role as a project partner, encouraging and coordinating the adhesion by other sea and inland ports through the identification of new shared research topics and acting as a focal point for port managers for the exchange of best experiences and environmental practices.

The ECOPORTS research project focused on the development and implementation of tools to improve the environmental performance of ports. The project involved 26 partners: 13 ports and port organizations had the operational guidance, while 5 universities and 8 experts provided environmental skills and training skills. From 1 June 2002 to 1 June 2005, the project focused on the creation of a European "Ports & Environment" network, which involved all the main European seaports and inland ports. At the end of 2007, the ECOPORTS network had 40 partners from 18 countries in Europe and South-East Asia.

For its entire duration, the ECOPORTS project has developed a database with more than 150 solutions related to the most important environmental problems of European ports, reported by the ports themselves. The main topics covered are the following:

- air quality;
- habitat management;
- waste management;
- port city;
- logistics chain;
- noise management;
- dust.

Regarding noise management, NoMePorts (see the next section) is one of the projects under the ECOPORTS framework. As a result of the collaboration of the different ports, ECOPORTS has a database with an important number of documents related to noise management:

- noise measurements, Port of Amsterdam;
- allocation policy for noisy ferry ships, Copenhagen Port;
- noise reduction near the container terminal, Port of Dublin;
- modernization of the road transport network, Port of Gdansk;
- acoustic study for the noise of port activities, Port of Genoa;
- limitation of activities at night, Port of Gent;
- echo-driving of goods handling vehicles, Port of Gothenburg;
- ground supply of electricity to ships, Port of Gothenburg;
- new noise emission limit values, Port of Hamburg;
- reduction of noise pollution installation of thermal break double glazing on the windows, Larne Port;
- reduction of disturbance, Port of Malta;-
- water course management, Port of Milford Haven;
- noise reduction of port activities, Port of Oslo;
- definition of real noise levels, Port of Rotterdam;
- noise management system for industrial noise, Port of Rotterdam.

NoMePorts

The NoMePorts project [2] was funded by the LIFE program of the European Commission. The main objective was the reduction of noise and nuisance due to noise and health problems of people living around port infrastructures, through the creation of acoustic mapping and a management system. The project analyses the most efficient way to collect data and to create noise maps and experiences for the optimization of a noise management system for specific use within port areas.

The NoMePorts project started in November 2005 and ended in February 2008. Noise mapping and noise management were demonstrated in various Local Working Groups (LWGs), which created noise maps and action plan proposals on noise mitigation through the cataloging of noise mitigation measures. Local working groups discussed their results and guidelines with other ports participating in the Central Working Group (CWG). The partners of this project were:

- Port of Amsterdam (Project Leader);
- Port of Civitavecchia;
- Port of Copenhagen / Malmoe;
- Port of Hamburg;
- Port of Livorno;
- Port of Valencia;
- ECOPORTS Foundation (Project Management & Dissemination);
- Cardiff University (Scientific Coordination);
- DGMR (Noise Management Experts).

The observing partners are: Port of Bremen, Port of Gothenburg, Port of Oslo, Port of Rotterdam, Port of Tenerife.

Through the dissemination of the results, a common platform for noise mapping and port area management was promoted thanks to the use of the Good Practice Guide on Port Area Noise Mapping and Management guidelines developed during the project. This document includes a technical annex which provides further details and focuses on the use of software, information gathering and how to interpret the results of the calculation. The document underlines that the effectiveness and usefulness of these two documents has been confirmed and supported by the implementation of the strategic noise mapping in 7 pilot ports, applying the NoMePorts project methodology.

The creation of the acoustic mapping of a port is very complex due to the detection, classification and characterisation of different types of sources and for the identification of isolating curves defined by a certain value of L_{den} and L_{night}. With regard to this second aspect, they are part of the port area where the acoustic sources of interest are located, the residential areas, the neighboring areas with exposed receptors and the area between the sources of the port area and the exposed areas. The boundaries of the acoustic mapping correspond to the following values:

- L_{den} = 55 dB (A)
- L_{night} = 50 dB (A)

Therefore, only the areas with L_{den} values > 55 dB (A) and L_{night} > 50 dB (A) should be taken into account.

As regards the sound sources present in port areas, it is possible to make a first division between noise due to transport infrastructures and that generated by production activities. Roads, railways and air traffic belong to the first category of sound sources; as regards production activities, the following examples are reported:

- port services and infrastructures;
- terminals (goods handling, warehousing);
- industrial areas;
- machinery;
- construction, repair and maintenance of boats;
- sorting stations
- moored boats (engine noise on board).

There is a very important aspect that emerged in the NoMePorts project (also taken from the SILENV project) during the studies conducted to characterise the different noise sources present at a port: the contribution of ships to environmental noise derives mainly from the operation of internal combustion engines. Furthermore, it has been noted that the emission of noise during mooring periods is generally dominant over the emission of noise during navigation, due to the periods of time related to these operations.

The acoustic mapping was carried out with the help of a forecasting software that implemented the calculation model developed in the HARMONOISE / IMAGINE projects. This model inherited the sound power data determined in the aforementioned projects, as will be described below, and it is applicable to all types of sources (road, rail, air and industrial).

Having a database of the main noise sources present in the study area is the logical prerequisite in any attempt to produce an acoustic map. The process of modeling acoustic sources involves a decision-making process on two levels: first, the choice of the appropriate modeling option for each identified source; secondly, the collection of acoustic emission data that allows the attribution of the sound power values of each source. Regarding the ships considered fixed sources like industrial ones, the following data were requested:

- type of ship;
- tonnage;
- arrival and departure times;
- mooring position;
- time of stay.

As mentioned above, after constructing a database of all noise sources, verification of significance is necessary to avoid collecting unnecessary noise data. For example, light vehicle traffic can generally be overlooked because heavy traffic is usually prevalent as regards noise emission.

The most innovative part in the characterisation phase of the sound sources was the determination of the sound power emitted by different industrial sources typical of port areas, including also moored ships. Noise data from industrial sources can be obtained by direct noise measurements or by using the default values (permissions, limits, specifications) and available databases (for example, the Source DB database). Direct noise measurements, performed using established techniques, dedicated equipment and software, are considered the most accurate option. However, measurements can be time-consuming and often technically complex: ideally, the source under investigation should be isolated from any other background noise to consider an accurate measurement. The validation of this type of data, in general, can be carried out by means of measurements only for a small sample of the most significant sources. Another approach for collecting acoustic data may be to correlate information provided by different authorities and sources. For example, regarding the acoustic mapping of the Port of Livorno, the IMAGINE project database was used to assess the noise contribution of ships. Since the goal of the NoMePorts project was to create an acoustic mapping of the port, the main work was to determine the annual statistical data of the berthed ships, for each category.

From a careful analysis of the NoMePorts project, therefore, it is possible to draw two important conclusions:

- regarding the noise generated directly by the ships, the noise linked to maneuvering periods (docking, departure and transit) may be neglected, while it may be considered to be caused mainly by the presence of the engines coming from the ship at dock;
- for the evaluation of the contribution produced by the ships at mooring, it is necessary to have information such as the sound power level, the type of boat, the tonnage, the mooring position, the time spent.

HARMONOISE and IMAGINE

As part of the NoMePorts project, the modeling of sound sources was developed through the use of the calculation method developed for the HARMONOISE / IMAGINE project. It is therefore considered appropriate to briefly describe the projects that resulted in the creation of this method, in particular with regard to industrial noise, the subject of the IMAGINE project. In the context of HARMONOISE [3], attention was focused on forecasting methods for road and railway sources, while the IMAGINE project [4] involved both airport noise and industrial noise. The latter category of sources also includes port sources: the IMAGINE project has standardised the methods already developed in HARMONOISE and has provided guidelines on how to use these methods for the preparation of acoustic mappings and related remediation. The methods have been developed to predict noise levels in terms of L_{den} and L_{night}, which are harmonised acoustic descriptors based on the END.

The HARMONOISE project began in August 2001 and ended in January 2005. The consortium was formed by 19 European organizations specialized in measurements, propagation and forecasting models of environmental noise. The main products of the project consist of reports concerning the description of the source, the measurement methods, the propagation models and the database with the measurement data, the parameters of the sources. Furthermore, the HARMONOISE project proposed to distinguish between the emission of noise and its propagation, with the great advantage that a generic model of noise propagation can be used for all types of sources.

The IMAGINE project began in December 2003 and ended in December 2006. The Consortium was made up of 27 partners, including 7 research institutions, 9 consultants, 5 industrial organizations, 2 non-governmental organizations and 4 universities. All came from 10 different member states of the European Union and two other European countries (Norway and Switzerland) that were not part of the Union. Twelve of these partners had already been involved in the HARMONOISE project.

The main outcomes of the project are the guidelines that describe how to measure source data within the calculation methods developed in HARMONOISE, and how to deal with aircraft noise and industrial noise. The Source – DB database was also provided, containing all the features of the modeled sources.

To evaluate the sound power levels of industrial noise sources, such as electric motors, pumps and compressors, fans, ovens, boilers, refrigerators, etc. the following approaches have been identified:

- determination of the sound power level noise of the sources by measurements carried out near the source itself or further away along the noise propagation path;

- acquisition of the data declared by the source producer;
- data use from databases available for the specific source.

The database considers three noise reduction classes, with the following interpretation:

- Poor: noise mitigation measures have not been adopted and the source is obsolete or affected by poor maintenance. Sound power levels are not always based on detailed measurements, but some examples have been found in the literature.
- Average: some noise mitigation measures have been adopted and the source is adequately maintained. If no further information on the specific source is available, it can be considered as having middle class noise reduction.
- Good: the sound power levels of these sources are among the lowest on the market. However, it has not been verified whether these sources can be considered among the best available technologies.

The default values refer to the typical levels of sound power emitted by a specific industrial activity per unit area, taking into account the noise reduction classes mentioned above. This approach is valid for many industrial activities, for example for petrochemical plants, power plants, shipyards, etc. The source database provides the spectrum of average sound power levels in third-octave frequency bands, both for single sources and for total installations, obtained on the basis of provisional measurements and calculations.

The best way to collect sound power data is to take noise measurements on each source. In addition to the acoustic emission measurements, the following parameters must be acquired:

- position and height from the ground of the noise source;
- dimensions and orientation;
- type of source (for example, punctual, linear or superficial);
- operating conditions of the source;
- directivity for each operating condition;
- operating times (day, night and seasonality).

The estimated hours of operation for the day, evening and night periods, based on an annual average, is important for assessing a correction coefficient in dB, for the purpose of calculating the noise levels expressed in L_{den} and L_{night} issued by the considered source. This correction factor must be subtracted from the sound power level.

Among the types of industrial sources described in the database, various types of ships are reported. Among the various operating conditions, only mooring was considered, as it was considered the most significant for the purposes of calculating noise levels. The ships were modeled as a punctiform source located at the pier; as far as the height is concerned, it has been reported in relation to the decking floor of the dock and linked to the ships tonnage:

- for tonnage below 2,000 tons, the height is 15 m from the quay level;
- for tonnage over 2,000 tons, the height is 25 m from the quay level.

As far as the port is concerned, in the industrial sources database there are other port areas modeled as surface sources at a height of 5 m from the ground: gas terminals, multi-purpose terminals, shipyards and marshalling yards.

SIMPYC

The SIMPYC project [5] represents a significant contribution to the self-regulation of ports and cities. The objectives of the project include the search for solutions to some of the problems deriving from the relationship between the port and the city, in order to establish a more ecological and functional relationship model, as well as to improve the coordination of port activities and the municipal administration.

A good relationship between the city and the port, in fact, offers benefits both for the inhabitants of a city and for the rest of the interested parties, also helping to create a positive image of the port and the city itself. The project also proposed to provide solutions for the low level of environmental management concerning the small economic activities taking place in the ports of small municipalities (trade, fishing, etc.), as in most cases they are no environmental management systems in place. In cases where such systems exist, they are usually independent from the environmental management carried out in the rest of the municipality. In this sense, the project has set itself the objective of establishing a standard for Environmental Management Systems for small port infrastructures.

The SIMPYC project began in August 2004 and lasted three years. The project was coordinated by the Port Authority of Valencia, with the collaboration of the ports and municipalities of Spain, France and Italy. The other partners who participated in the project are:

- Port Authority of Livorno;
- Municipality of Livorno;

- Chamber of Commerce of Var;
- Municipality of Toulon;
- Municipality of Valencia;
- Valencia Department of Infrastructure and Transport of Valencia;
- University of Valencia;
- Ente Público Puertos del Estado (Public body coordinating Spanish ports);
- Fundación Europa Comunidad Valenciana-Región Europea;
- Azahar Ingeniería, S.L.

Among the main objectives identified by the SIMPYC project, the most interesting are:

- coordinating environmental management processes implemented in urban and port environments, as well as coordination between administrations;
- developing joint initiatives to monitor the environment in the city-port interface, highlighting the monitoring and control of air quality, noise pollution and unwanted visual impacts.

HADA

In Spanish ports, noise is one of the environmental priorities of port activities. For this reason, it was necessary to work for the development and implementation of innovative environmental tools, in collaboration with the Port Authorities, to facilitate the environmental control of their activities. To this scope, the HADA project [6] was developed in the period of 2002-2005 within the framework of the LIFE program of the European Commission.

The HADA project is a tool designed to set up a control methodology for noise levels in Spanish seaports. It also includes the measurement of air quality, as well as the design of a decision support system for air pollution cases. HADA noise management involves the design of the acoustic monitoring network of the port of Bilbao (Basque Country) as a test port, as well as the analysis of its application to other port environments. It also implies the definition of a methodology for assessing the noise levels produced by the activities of the port, with its application corresponding to the port of Bilbao, noise mapping, analysis and recommendations for improvement.

In the port of Bilbao, after a specific analysis of all noise sources, it was determined that, as is the case of most ports, the main sources of noise are the displacement of metallic material (such as containers, steel processing or waste irons) and the traffic of trucks and trains (with the exception of special cases), while ships are generally a medium-low source of noise impact. This is why the HADA project is not particularly focused on maritime transport, whereas the noise emitted by loading and unloading activities are important sources of noise.

To reach these conclusions, HADA has developed a noise management plan, which is defined as a continuous, systematic and documented way to manage the impact of noise on people and the environment of a port. The main objective of these plans is the prevention of impacts and the reduction of an already existing negative impact. The Bilbao Port Noise Management Plan included the following steps that can be perfectly applied to other ports.

Identification and characterisation of the main noise sources of Bilbao's harbour

The first step was the classification of the various noise sources according to their ability to generate impacts. Each of them has been documented with the occupied position, the parameters of movement of materials characterising them (number of containers, number of trucks, number of trains, etc.) and it has been associated with a specific modeling, linear or areal, depending on its mode of operation.

Evaluation of noise levels

This evaluation includes the creation of a network of ports, consisting of two monitoring data collection systems at the terminals, a portable system currently located near a container terminal and a Central Processing Unit. To apply this method to other ports, it is important to consider that the size of the monitoring stations network will depend on the specific port environment, the different types of sound sources and their location with regard to urban areas, the number of complaints, etc.

In general, the assessment of noise impact can be carried out using two different methods: use of monitoring systems and provisional models. Monitoring systems are the most traditional systems, of very common use in urban contexts (for example, Madrid, Bilbao, Barcelona, Valencia). They are generally accompanied by another type of environmental monitoring system (air). The disadvantages of monitoring systems are reported as follows:

- results dependent on weather conditions;
- results referring to a limited area;
- initial investment and maintenance costs;
- influence of environmental sources not related to the object of measurement.

The provisional models, on the other hand, have not been the subject of detailed studies during the project, as they are more oriented towards the intervention of the port authorities. The methodology used has combined measurements of the noise level (monitoring systems) with the application of the calculation model, in order to obtain detailed and complete data. The measures allowed to establish the emission levels characteristic of the various noise sources, while the levels perceived by the receptors were calculated with the application of the calculation methods. In general, the mutual compensation of any shortcomings of each method of diagnosis seems to suggest the combined use of both. Therefore, based on an acoustic map developed with provisional models calibrated with the data obtained from the monitoring system, a complete control can be performed on different port activities in order to avoid and mitigate any noise impacts.

Elaboration of noise maps for different sources of environmental noise

Due to the complexity of the activities taking place at a port (variable in time and space), a series of scenarios has been defined, allowing the representation of average situations. Based on three scenarios (day, evening and night), aspects such as the positioning of the sources at the port area and weather conditions were combined, in order to produce a total of 16 acoustic mappings. Two options have been taken into consideration in defining the meteorological conditions: on the one hand, the European Commission's proposal for the application of the END and, on the other, the local conditions of wind speed and direction. The 16 acoustic maps obtained for the port of Bilbao are a representation of the data relating to the following aspects:

- existing, previous or planned acoustic situation, expressed as a function of an acoustic descriptor;
- exceeding a limit value (conflict map);
- number of homes in a given area exposed to a range of values of an acoustic descriptor;
- number of people exposed (annoyances, sleep disturbances, etc.) in a specific area;
- economic relationships between costs and benefits or other economic data on corrective measures or other measures against noise.

The sound propagation for the determination of the acoustic mapping was carried out by applying acoustic models suitable for each type of source (*French road model, Dutch railway model, ISO 9613 standard for industrial sources*).

In parallel with the mapping calculation, the estimation was carried out on a series of receptors placed on the façades of the most exposed residential buildings. The information obtained for each of the receptors was then used to carry out the subsequent evaluation of the acoustic impact generated by the entire activity of the port, to establish a correlation between the detected sound levels and the inhabited area, and finally to determine which sources are predominant.

Analysis of risk areas and implementation of noise mitigation measures

Once the acoustic mappings and the results of acoustic modeling for the port of Bilbao were obtained, a screening process was developed for "significant groups of noise sources", intended as the sources that strongly contribute to environmental noise levels. Once this type of analysis has been carried out, it is important to differentiate hot spots and the size of the population exposed, in order to define and implement noise mitigation measures.

According to the acoustic mapping obtained for the port of Bilbao, the most significant sources have been associated with road traffic (trucks), trains and the handling of metal elements (such as containers, steel industry operations, etc.). Therefore, any kind of remedy aimed at reducing or eliminating these impact situations must be directed to these three main sources. The other noise sources should be studied but taking into account the actual noise levels associated with them. Furthermore, according to the results of the project, it is important to remember that, even in the ideal case where the port is the main source of noise, when a noise mitigation program is established for a hypothetical acoustic impact, the difficulty of differentiating the contributions of a certain source among the whole set of activities present at the port is added.

According to the main noise mitigation measures implemented at the port of Bilbao, the current situation has the advantage that these three noise sources had been extensively studied over the years, and the possible corrective actions to be carried out are well known and can almost be considered as standardised. Among these standard solutions, acoustic shielding, the use of draining surfaces for roads and modifications of the railway line (avoiding welded joints) can be taken into consideration, so as to improve the fastenings (elastic) by properly maintaining the rail surface (avoiding roughness) or using the correct type of separate sleepers.

The results showed that it is not very common to find an area of houses or buildings with particular sensitivity to noise (schools, hospitals, cultural centers, etc.) that are exposed only to the influence of port activities. Since the presence of other environmental noise sources (roads or railways) is very common, they can interfere in the result of the measures, and therefore it is difficult to make a direct assessment of the specific impact of the port.

Finally, it must be considered that the port of Bilbao is an industrial port, therefore the main acoustic sources may vary depending on the activity of each port (commercial, fishing, etc.); however, the HADA project was one of the pioneers in the development of such projects in Spain, so the results are very interesting for obtaining conclusions and action plans for other Spanish ports in the future.

SILENV

The topic regarding the characterization of the ship source has been addressed in the SILENV project [7]. A series of complementary measures have been identified, in addition to those recommended by international technical standards. In order to adapt to the wide variety of ships and noise sources present inside a ship, a flexible approach to define the survey parameters was chosen.

The complementary measures suggested by the SILENV project for dockside ships are:

- different lines of measurement points along the ships hull at different distances from it, so that the overlapping of local sources can be analysed;
- measurement points positioned at different heights with respect to the dock, with the aim of evaluating the sound propagation of higher-placed sources, such as the ventilation, intake and exhaust systems, which are located at a certain height on one side of the ship either over a bridge or in the highest part of the superstructure;
- measurement times as a function of the source emission duration.

For ships in navigation, the measurement objective consists of defining a significant sound level that acoustically describes the transit of a ship. Generally, pass-by tests are commonly used to measure the noise emitted by a mobile source.

In order to create an acoustic map in terms of L_{den} and L_{night} for the noise emitted by the ships in port, numerous input data are required, including:

- the cartography of the port area, including the areas where the different types of ships usually dock and the transit lines that ships normally travel;
- the acoustic characteristics of the different types of ship (sound power level depending on the ships operating conditions, directivity of the sources, etc.) that together characterise the ships emission;
- the number of ships moored to the dock for each type of ship: annual averages for each period of the day (day-evening-night);
- the number and duration of transits for each type of ship: annual averages for each period of the day (day-evening-night).

The percentage of people exposed to high levels of L_{den} and L_{night} can be evaluated based on noise maps. Furthermore, by comparing noise levels with regulatory limits, it would be possible to identify critical areas from the point of view of noise pollution. Unfortunately, at the present moment there are no sound limits for the noise emitted by ships. The situation is the same for other types of sources. If it were possible to identify these critical issues, it could be decided in which port areas it would be more appropriate to have the ships docked in such a way that these have a lesser impact on the residents near them.

As part of the SILENV project, procedures have been developed aimed at characterising the noise emitted by boats in moored conditions. These procedures are described below as they are used during the measurements made.

Moored vessels: first measurement method

The measurements are to be made on a grid of points, defined below, which lies on a parallelepiped measuring surface. The faces of the parallelepiped are oriented in directions parallel to the plane of symmetry of the ship and normal to it. The A-weighted sound pressure level, estimated as an average over a 30 second time (as suggested in the *ISO 3746: 2010* standard), must be measured at each point. Reference is made to the *ISO 3746: 2010* standard to consider corrections for background noise. The grid points must be spaced in two directions of the quantity *d* defined as follows:

- for vessel length L <100 m, d = 6 m;
- the length of the ship L> 100 m, d = 10 m.

Regarding the positioning of the measurement points along the parallelepiped surface, at the selected distance of 10 m, the following two options are provided [8,9,10]:

1) a grid of points with dimensions of 10 m above the maximum extension of the ship in each of the three directions (Figure 6.1);
2) to limit the number of measurement points, the grid can be limited following the longitudinal profile and the transversal profile of the ship increased by 10 m in all directions (Figure 6.2).

The previously defined grids must be positioned on the side of the ship, in order to cover an acoustic dissymmetry often found in the acoustic emissions of ships.

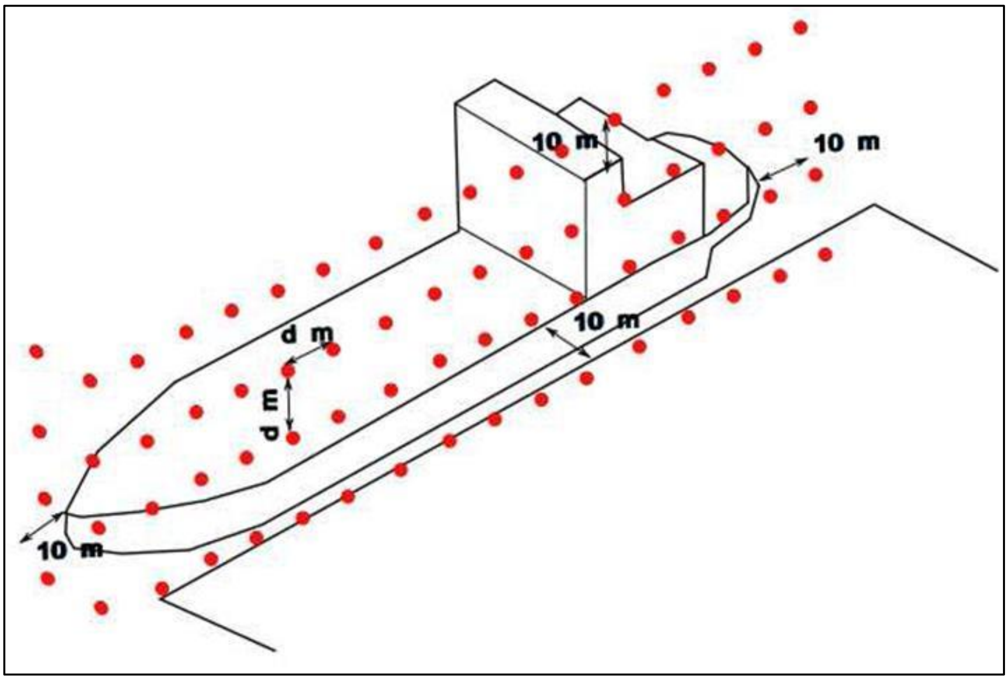

Figure 6.1: Option 1 for the measurement point grid of a moored ship.

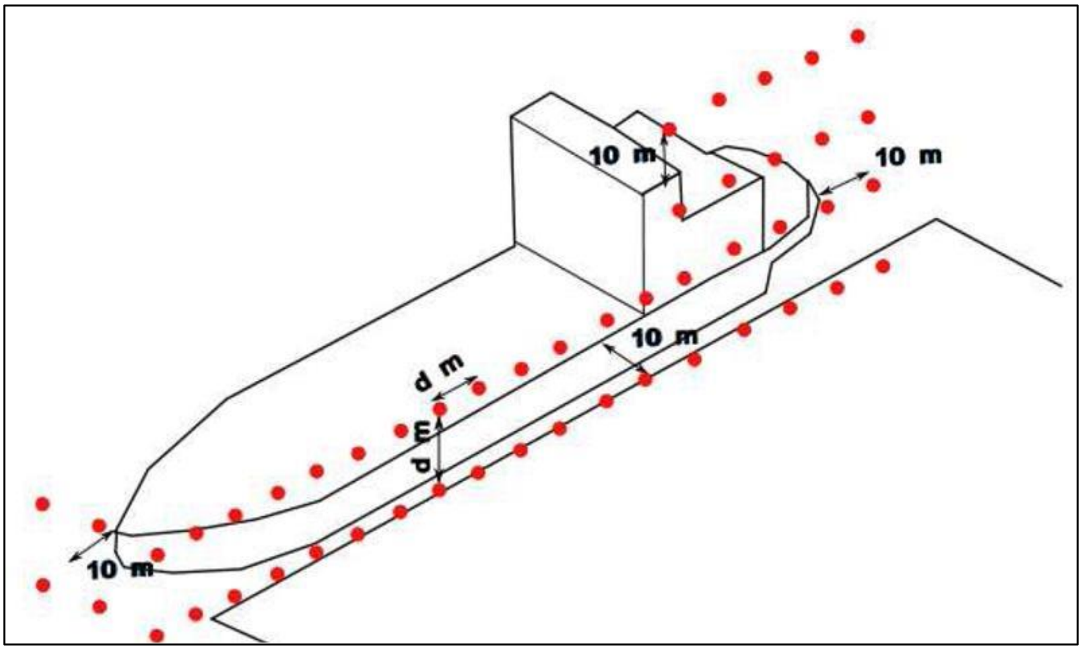

Figure 6.2: Option 2 for the grid of measurement points of a moored ship.

Moored vessels: second measurement method

The above described procedure is the suggested procedure for a correct characterisation of noise emission from the ship. When it is impossible to perform measurements on the surface of the parallelepiped, an alternative criterion can be used. In this case the measurements can be made along a horizontal line of points at a level 1.2 m above the ground at a distance of 25 m from the ship side. Points must be spaced by the quantity d defined as follows:

- for vessel length equal to L <100 m, d = 6 m;
- for ship length equal to L> 100 m, d = 10 m.

Furthermore, no obstacles should interpose between the ship and the measuring points. Figure 6.3 shows the arrangement of the measurement points with this alternative method [11].

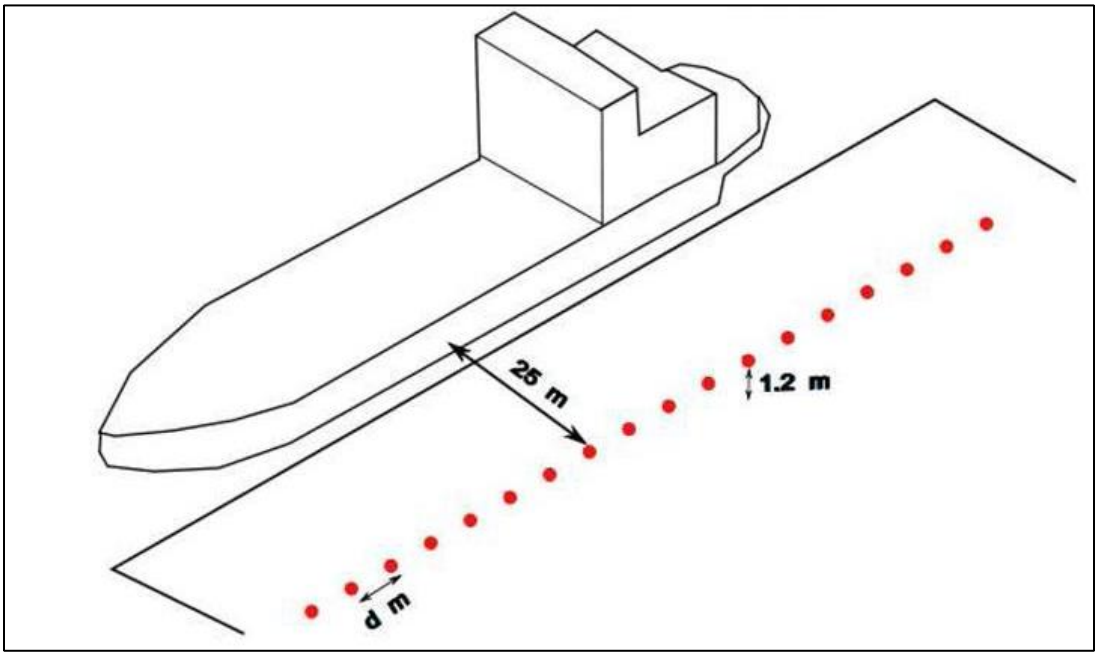

Figure 6.3: Alternative method for the grid of measurement points of a moored ship.

6.2 *Measurement campaigns of national control bodies*

This section reports the most significant measurement experiences relating to the most important Italian ports, carried out in recent years by public environmental control bodies.

Measures of the Province of Genoa

The Province of Genoa has started a phonometric survey of port noise since 2005 [12], an activity intensified in the two-year period of 2008-2009. The main objectives of the monitoring were the verification of the sound levels present in some inhabited areas close to important port infrastructures and the identification of an adequate technical approach for the peculiar case of Genoa.

The monitoring campaign included both continuous multi-day findings and “spot” measures on short time (in practice less than or equal to 1 hour). Particular attention has been paid to performing surveys (also long-term) in frequency band, considered essential to discriminate the contributions of the acoustic noise source, in the almost stationary examined cases and with some characteristic emission bands, from the complexity of other noise emissions due to an urban context in which the phonometric survey was carried out. The inhabited area of Multedo, located within the Genoese urban fabric, near an important port infrastructure, was taken into consideration (Figure 6.4).

Furthermore, the built-up area of Multedo is affected by noise emissions caused by important transport infrastructures: the Via Aurelia, the A10 motorway with its junction, the Genoa-Ventimiglia railway, the C. Colombo airport. The main sources of noise relating to the activities at the Port of Petroli, pumping and ship engines, are essentially continuous and stationary. Based on reports from its citizens, the disturbance caused by ships is especially noticeable during the night and in areas of the town that are located in the hills.

Several weekly surveys have been carried out at three separate sites located along the Via Aurelia (VR) and along a local road that winds along the hill (VC1 and VC2). In addition, 20 spot measurements were also carried out on short acquisition (from about 15 minutes to about 1 hour); these last ones in 3 sites (S1, S2 and S3 in the following) have been repeated on different dates and times. All sites are located within the first 100 m from the border of the port area.

Figure 6.4: Multedo area (GE).

Figure 6.5 schematically shows the positions of the continuous measurement sites (VR, VC1, VC2) the most significant spot measurements (S1, S2, S3, S4); the routes of the Via Aurelia (blue color) and of the railway (red color) are also highlighted.

The location of the VC2 monitoring station was also identified in consideration of a preliminary study done on surveys carried out simultaneously on the two sites VR and VC1. This study have shown that the VR site is affected by noise levels influenced decisively by vehicular traffic of Via Aurelia, while the VC1 site confirms that the hilly area is suitable for continuous monitoring, also aimed at estimating the noise emissions of the origin port. The VR point, in fact, is located in a large square at the side of Via Aurelia; behind the VR, towards the mountain, the Genoa - Savona (elevated) railway line runs partially shielded. On the other side of the road, beyond some buildings, there are port infrastructures. On the other hand, the VC1 site is located at a local road on the Multedo hill, partially shielded with respect to Via Aurelia and the railway but not with respect to the port: the VC2 measuring point was located along the same road.

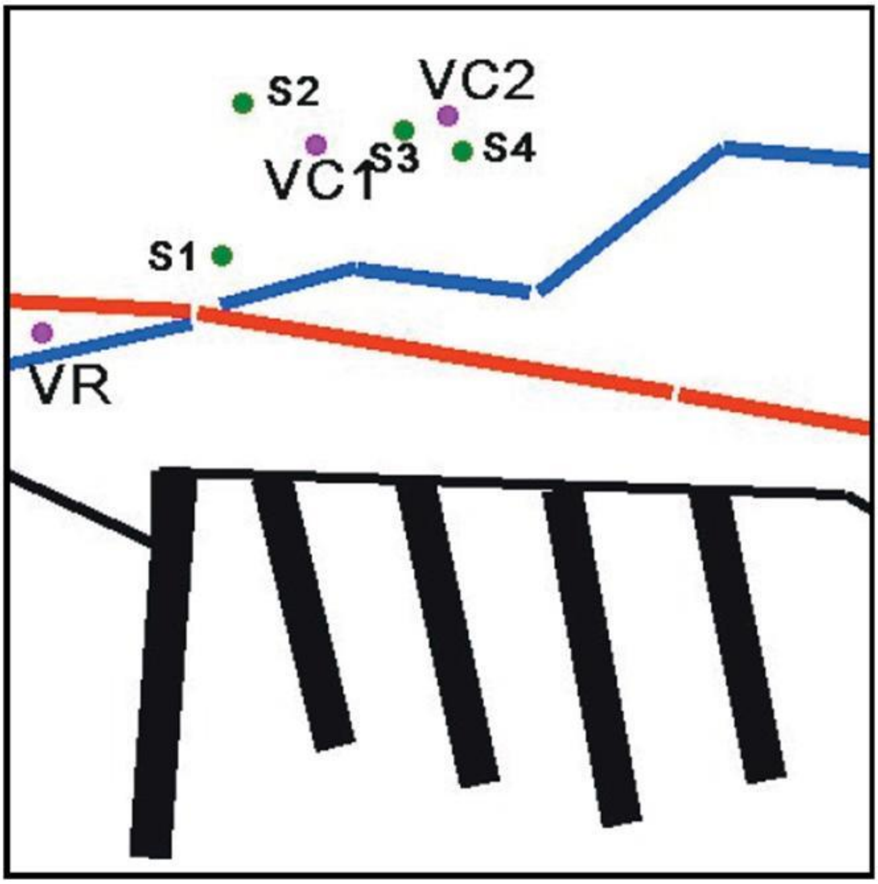

Figure 6.5: Spot measurement stations (S1, S2, S3 and S4) and continuous (VR, VC1 and VC2), used for monitoring in the Multedo area (in blue the Via Aurelia and in red the railway).

In order to quantify the differences between the sound levels monitored in VR and VC1, with the aim of verifying the suitability of the hilly area for the subsequent continuous monitoring, the preliminary study had primarily considered the levels detected at night-time, more suitable to highlight almost stationary sound phenomena such as acoustic inputs possibly coming from the port area. The statistical analysis of the L_{Aeq} and of the A-weighted percentile levels, measured in the VR and VC1 sites revealed the substantial acoustic inhomogeneity of the two sites. In fact, the highest correlation between the monitored data was obtained in the case of L_{10}, which saw a correlation factor of 0.74, while for L_{Aeq} a value of 0.71 was obtained. Thus, the correlation decreases rapidly as the order of the percentile increases, resulting minimal for L_{99} (0.31). The poor correlation for background levels had provided a further indication of higher suitability of the hilly area for the monitoring of sound phenomena associated with the port.

Table 6.1 shows the average levels of LA_{eq} for three typical days (weekdays, Saturdays and holidays), relating to the day and night reference periods, measured at the VR, VC1 and VC2 sites.

Table 6.1 - Measured values of L_{Aeq} in dB (A), relative to the day and night reference periods, in continuous measurement points (VR, VC1 and VC2).

Spot	Weekday		Saturday		Holiday	
	L_{Aeq} daytime	L_{Aeq} nightime	L_{Aeq} daytime	L_{Aeq} nightime	L_{Aeq} daytime	L_{Aeq} nightime
VR	72.6	67.6	71.9	68.6	70.9	68.7
VC1	56.5	51.7	56.4	52.9	58.2	52.0
VC2	58.8	55.2	58.1	54.3	57.5	55.2

Figure 6.6 graphically shows the arithmetic mean (and standard deviation) spectrum values for the L_{99} percentile data set (night time) in the presence and absence of ships at berth (linear weighting, dB), measured in the February – March period.

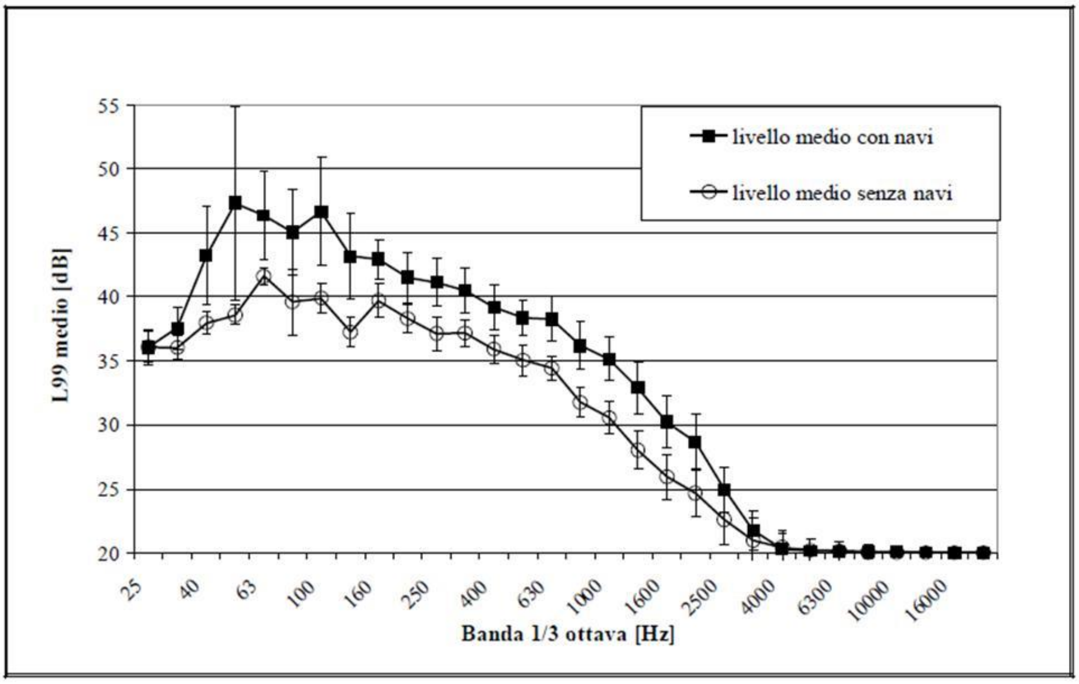

Figure 6.6: Average spectra and standard deviations for L_{99} at night of the measurement point VC2, data from the February-March period.

It is noted that in the presence of ships at mooring the average spectrum tends to be higher, in particular at low frequencies (40 ÷ 160 Hz) and significantly for some frequency bands in the middle part of the spectrum. Furthermore, for significant frequency bands, in the absence of ships, the standard deviation is much lower (0.7 ÷ 1.3 dB) than with the presence of ships (1.7 ÷ 7.6 dB): further evidence of the variability of sound emissions of port origin due to both the inhomogeneous emission characteristics of the individual ships, and the variability of the number of ships present.

In terms of global A-weighted levels, monitoring at the VC2 site provided values of L_{99} average hours (night-time) with presence and absence of moored ships (again for the February-March period) respectively equal to 46.4 dB (A) , with standard deviation equal to 1.7 dB (A), and 42.1 dB (A) and standard deviation of 1.1 dB (A). Moreover, at the measurement sites on short time S1, S2 and S3, night measurements were carried out with the presence of ships in port. In terms of L_{Aeq}, the night session provided the following values: 58.9 dB (A) (S1), 55.5 dB (A) (S2) and 55.5 dB (A) (S3). The highest value corresponds to site S1, which is closer to the port infrastructure and less shielded than the others with respect to the Via Aurelia which, however, had minimal traffic even though it was rather scarce. The levels detected at sites S2 and S3 are fully compatible with the average nightly L_{Aeq} value for the VC2 site.

7. Noise measurements campaign in ports

7.1 *Italy*

In the period between November 1999 and August 2000, measurement campaigns were carried out including SPL measurements at the port perimeter and in correspondence with the receptors most exposed to the identified sources [13]. Continuous measurements have been made, for a duration of at least 24 hours, and acoustic surveys of shorter duration, in correspondence with some periods considered more critical.

The phonometric investigations were carried out by the competent administrations in the matter of controls for each territory considered and by the ANPA (National Agency for Environmental Protection, now ISPRA - Higher Institute for Environmental Protection and Research) which carried out the survey at the port of Messina (Table 7.1).

Table 7.1 - Administrations that carried out the investigations at each port.

Port	Administration
Bari	PMP of Bari, Physical - Environmental Sector Division of Acoustics and Vibrations
Civitavecchia	ARPA Lazio
Genova	ARPA Liguria
Livorno	ARPA Toscana
Messina	ANPA

The measurement campaign has provided for each selected site the determination of the day and night LA_{eq}, both continuously, for a duration of 24 hours, and with stations manned for a duration of a few hours. The choice of manned measures was carried out where there are more noise sources with the consequence that the port component on the global noise can be masked by the other components. In some ports, in addition to LA_{eq}, the statistical parameters L_1, L_5, L_{10}, L_{90}, L_{95}, L_{99}, the SEL related to single events and relative frequency analysis were also detected.

Port of Bari

The port of Bari is a multi-purpose port; in its basin, of about 285 hectares, are included:

- docks equipped for all types of commercial traffic (solid and liquid bulk, containers, packaged goods, iron and steel products, etc.);
- docks serving Ro-Ro ferry boats;
- docks serving the stable for horses and cattle both in import and export;
- docks equipped for the marketing and processing of Atlantic fisheries;
- docks for cruise ships and related accommodations for cruise passengers.

The versatility of the port is facilitated by its direct connection to the railway network and to those roads and motorways, which allow the rapid connection with all industrial, agricultural and commercial centers of Southern Italy. This circumstance, together with the assortment of infrastructures, has preserved in Bari the role of one of the most important commercial ports of the south in relations with the markets of the Balkan peninsula and the Middle East. The maximum activity time slot, in relation to the operating times of the noisy sources, is between 06.00 and 23.00 from Monday to Friday.

Based on the type of settlement and the noisy sources present in it, a measurement point has been defined, located outside the port, 1.5 m from the perimeter. The measurements were carried out with a microphone equipped with a windproof headset, directed towards the noise source, at a height of 1.5 m from the walking surface. The phonometric surveys provided for a total duration of 24 hours: from 8.00 pm on 11/01/2000 to 8.00 am on 12/01/2000 and from 8.00 am to 8.00 pm on 13/01/2000.

Table 7.2 shows the results of the measurement performed at the port perimeter.

Table 7.2 - Values of LA_{eq} in dB (A) measured at the port of Bari.

Reference period	L_{Aeq}
Daytime	70.0
Nightime	57.0

The identified measuring point is located at the perimeter of the port. No measurements were carried out at the nearest receptors, which are located at about 100 m from the other entrance to the port, characterised by noise levels presumably comparable with those measured or below.

Port of Civitavecchia

The port of Civitavecchia represents one of the most significant structures in the national field, both for the loading and unloading of goods, and above all for the transit of passengers to Sardinia and an increasingly intense cruise movement in the summer period. Thanks to its geographical position in the center of the Italian peninsula, the port of Civitavecchia is today one of the strategic structures at national and European level for the handling of all types of goods and is a reference point for all of central Italy and in particular for the industrial and commercial area of Rome.

In order to assess the level of acoustic input present within the Civitavecchia port, in December 1999, in addition to the measurements already carried out in the summer, some acoustic surveys were carried out in correspondence of a receiver near the port perimeter. The measurements were carried out at an apartment located at about 15 m above sea level and about 50 m from the dock. It should be noted that between the receiver and the dock there is a road characterised by an intense vehicular flow but differentiated in the two summer and winter periods. During the summer, the area is open to vehicular and railway traffic when the ferries from Sardinia dock, while in winter the passenger transport activity is somewhat reduced while there is an intense activity of maintenance and restoration of the port area with intense passage of heavy vehicles for the transport of materials. In particular, at the measurement station, L_{Aeq} surveys were carried out during the whole day and night reference period. Table 7.3 and 7.4 show the day and night L_{Aeq} values with the relative averages, referring to the measurements performed in the summer period and in the last autumn-winter campaign.

Table 7.3 - Values of L_{Aeq} in dB (A) measured at the port of Civitavecchia in the summer period.

Reference period	***L_{Aeq}***				
	19/06/1998	**21/06/1998**	**23/06/1998**	**24/06/1998**	**L_{Aeq} medio**
Daytime	69.8	68.6	70.6	70.2	69.9
Nightime	64.0	65.9	65.8	67.0	65.8

Table 7.4 - Values of L_{Aeq} in dB (A) measured at the port of Civitavecchia in the autumn-winter period.

Reference period	***L_{Aeq}***				
	02/12/1999	**03/12/1999**	**14/12/1999**	**15/06/1999**	**L_{Aeq} medio**
Daytime	68.7	69.0	68.4	67.4	68.4
Nightime	59.5	59.6	59.5	59.8	59.6

It is possible to observe during the night period an evident decrease in noise levels due essentially to the reduction of passenger traffic and the reduction of human activity on the port dock. The sound pressure level in the daytime period shows a substantially homogeneous trend during the observation period with the absence of particularly evident energy contributions with respect to the measurement period. During the night hours instead, there are characteristic peaks related to the movement and parking of ferries close to the dock.

In the reference period during the day the traffic of light and heavy vehicles is prevalent, which occurs near the receivers, in particular the traffic is given by the free circulation of the vehicles inside the port area and by the continuous movement of vehicles and machinery used for the restoration and maintenance of the docks with a discreet masking of the noise produced by the ships. In the nocturnal reference period, instead, the influence of the maritime movement is evident.

Port of Genoa

At the port of Genoa the main sources that cause problems of disturbance of citizenship are the following described:

- ship engines (including ventilation systems), during the docking phase;
- loudspeakers for signaling connected with passenger boarding-disembarking operations of the ferry and tourist terminal;
- handling of trailers;
- container handling, with particular reference to impacts during positioning and to the crane sound signaling systems;
- sandblasting operations.

In most cases the houses closest to the port are separated from it by roads with intense vehicular traffic and, in some cases, by railway infrastructures. For these reasons, it happens that the potentially most disturbed subjects may be the residents in the neighborhoods located at a height compared to the port area. In these districts, affected by local vehicular traffic, it is possible to warn, in particular circumstances (number of ships present in the port, type of ships present, wind direction, etc.), the continuous noise of naval engines. In these neighborhoods, therefore, the port noise contributes to the "area noise", although not predominant, if not sporadically, on the global noise induced by the aforementioned road arteries.

In November 1999, in addition to surveys already carried out previously, phonometric surveys were carried out in order to identify the level of port noise at some selected receptors. In particular, the following were performed:

- No. 10 measures monitored by staff;
- No. 1 continuous detection for 24 h.

The chosen sites were located along the perimeter of the port or at the most exposed receptors. In all the cases investigated, the main source to which the detected level was referred, was always identified.
In addition to the phonometric surveys carried out, the results of measurements already carried out at the Port of Petroli headquarters and those relating to other surveys previously done, were acquired. The complex of available data concerning the noise linked to the port has allowed to obtain a fairly complete picture of the noise emitted on the receptors by port activities in all its phases, spatially distributed for at least 10 km (over a global distance of about 20 km). Table 7.5 shows the investigated sources and the sites where the measures were performed.

Table 7.5 - Characteristics of the measured sources and of the sites of the attended measures.

Source investigated	Site	Distance in line with the source
Ship Engines	Banchina Porto Petroli	-
	V. Ronchi	200 m Porto Petroli
	Quartiere di Multedo	600 m Porto Petroli
	V. Buozzi	100 m Ponte A. Doria
	V. Adua	100 m Stazione Marittima
	V. Garbarino, V. P. Doria	200 m area porto
	L.go e Sal. S. Francesco	500 m port area
	Sal. S.Rocco	500 m port area
Ship Engines/ loudspeaker ferry	V. S.Fermo	300 m port area
	V. Barbareschi, V. Pescio	500 m port area
Ferry Engines / trucks	P.le S.Benigno	50 m port area
Commercial Port	V. Prà	100 m VTE
	L.go M. Canepa	20 m port area
Crane warning devices / container handling	Banchina VTE	-
	V. Villini Negrone	500 m port area
Industrial Port	P.le Mariotti	-
	Molo, V. Malapaga	20 m port area
	C.so Quadrio, C.so Saffi	20 m port area
	V. Mura Grazie	50 m port area
	V. Marina, Rot. S.F. d’Assisi	100 m port area
	V. Rivoli	300 m area Mariotti

Figure 7.1 shows a cartography of the port area with the exact location of the sites.

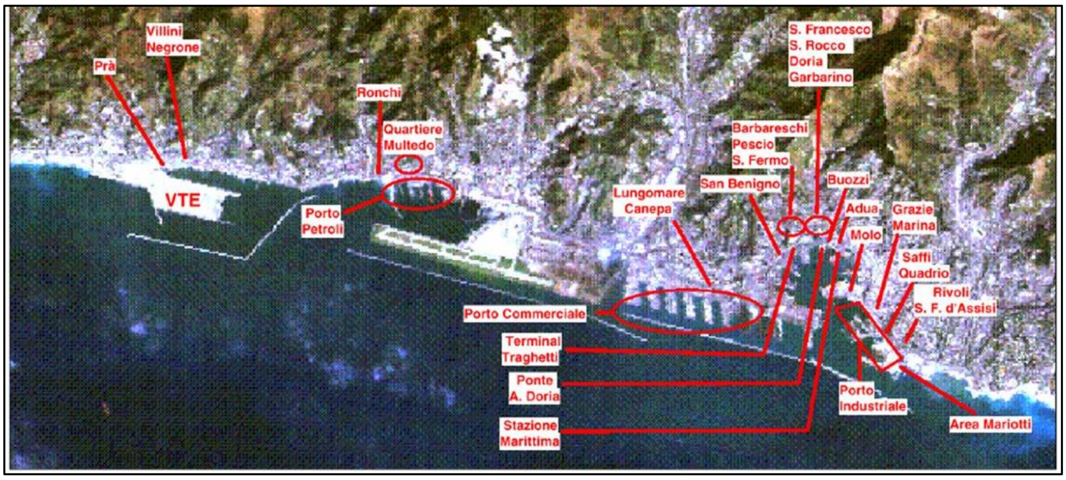

Figure 7.1: Plan of the port of Genoa with sources and measurement points.

Table 7.6 shows the results of the measurements performed at the selected points.

Table 7.6 - Results of measurements performed on the investigated sites, related to the reference periods day (d) and night (n).

Site	L_{Aeq}	Source
Banchina Porto Petroli	59-65(d)/52-56(n)	Ship engines
V. Ronchi	55-56(n)	Area/traffic/noticeable ship engines
Quartiere di Multedo	50-55(n)	Area/traffic/noticeable ship engines
V. Buozzi	76(d)	Road traffic
V. Adua	76(d)/68,5(n)	Road traffic
V. Garbarino, V. P. Doria	56/54(d)	Area/traffic/noticeable ship engines
L.go e Sal. S. Francesco	50,5/56(d)	Area/traffic/noticeable ship engines
Sal. S. Rocco	53(d)	Area/traffic/noticeable ship engines
V. S. Fermo	61(d)/57,5(n)	Area/traffic/noticeable ship engines and speakers
V. Barbareschi, V. Pescio	49,5-54(d)	Area/traffic/noticeable ship engines and speakers
P.le S. Benigno	63,5(d)/57(n)	Heavy traffic operating area / noticeable ferry engines
V. Prà	67(d)/61,5(n)	Road traffic / noise noticeable harbor
L.go M. Canepa	72-73(d)/67(n)	Road traffic
Banchina VTE	80(d)	Warning devices / crane / truck operating area
V. Villini Negrone	47(n)	Area/traffic/noticeable ship engines
P.le Mariotti	74(d)	Naval workshop Mariotti
Molo, V. Malapaga	52-60(d)	Area/workshops
C.so Quadrio, C.so Saffi	76-77(d)	Road traffic
V. Mura Grazie	71,5(d)	Area/traffic/noticeable ship engines
V. Marina, Rot. S.F. d'Assisi	60,5-61(d)	Area/traffic/noticeable ship engines
V. Rivoli	64(d)/60(n)	Area/traffic/noticeable ship engines

Table 6.7 shows the average L_{Aeq} value calculated respectively in the day and night period.

Table 6.7 - Overall noise measured at the port of Genoa.

Reference period	L_{Aeq}
Daytime	63.5
Nighttime	57.0

Port of Livorno

The port of Livorno covers the dual value of industrial / commercial port and passenger port, as well as performing the landing function for military naval units to a minimum extent. A schematic description of the activities taking place at the port and the possible impact on the nearby town is reported below. Within the port, large areas can be identified with a well-defined use destination:

- construction site: the shipyard “L. Orlando”, where activities are carried out for the construction of large naval units. The site is located in a densely populated area and is interested in the intense vehicular traffic of the waterfront;
- passenger terminal: in this area the operations of embarking / disembarking of passengers in transit from the port of Livorno take place, both by cruise ships and by ferries. Access to this area is through the same roads that transport traffic around the historic center; this port activity, which has its maximum in the summer months, determines an increase in the viability in these areas;
- Ami Wood area: in this part of the port the activities of handling of wood, wheat and paper are concentrated;
- petroleum zone: through the ducts that run along the oil dock, the oil tankers arriving at the port are emptied. The emptying activity takes place therefore in an area substantially far from the city;
- container terminal: a large part of the port activity takes place in this area, where container ships are loaded and unloaded. The maneuvering area of the goods is very far from possible receptors, but this activity involves a large number of heavy vehicles moving the containers outside and inside the port area through the highway that connects along the northern perimeter;
- mixed zone: similar to the previous one, it is an area dedicated to smaller goods and with different characteristics from all the previous ones;
- industrial area: in this area there are private industries that find advantage in being able to have a berth from which moving their goods or where bringing the materials they need. This peripheral area of the port is located in an exclusively industrial area and very far from the nearest residential settlement.

At the port in the period between 19 and 17 November 1999, 10 phonometric surveys were carried out continuously for at least 24 hours and some surveys monitored in situations characterised by multiple sources and not directly linked to the port. The location of the measurement sites is shown in Figure 7.2.

The measures monitored were carried out at the Via Orlando site as this site is located on a road subject to heavy traffic, so unattended measures could have led to an overestimation of the port contribution. During these manned measures the noise associated with the passage of some ships was detected, during observable pauses of heavy road traffic. At the port of Livorno in most cases it was not possible to position the instrumentation without falling into areas subject to significant road noise.

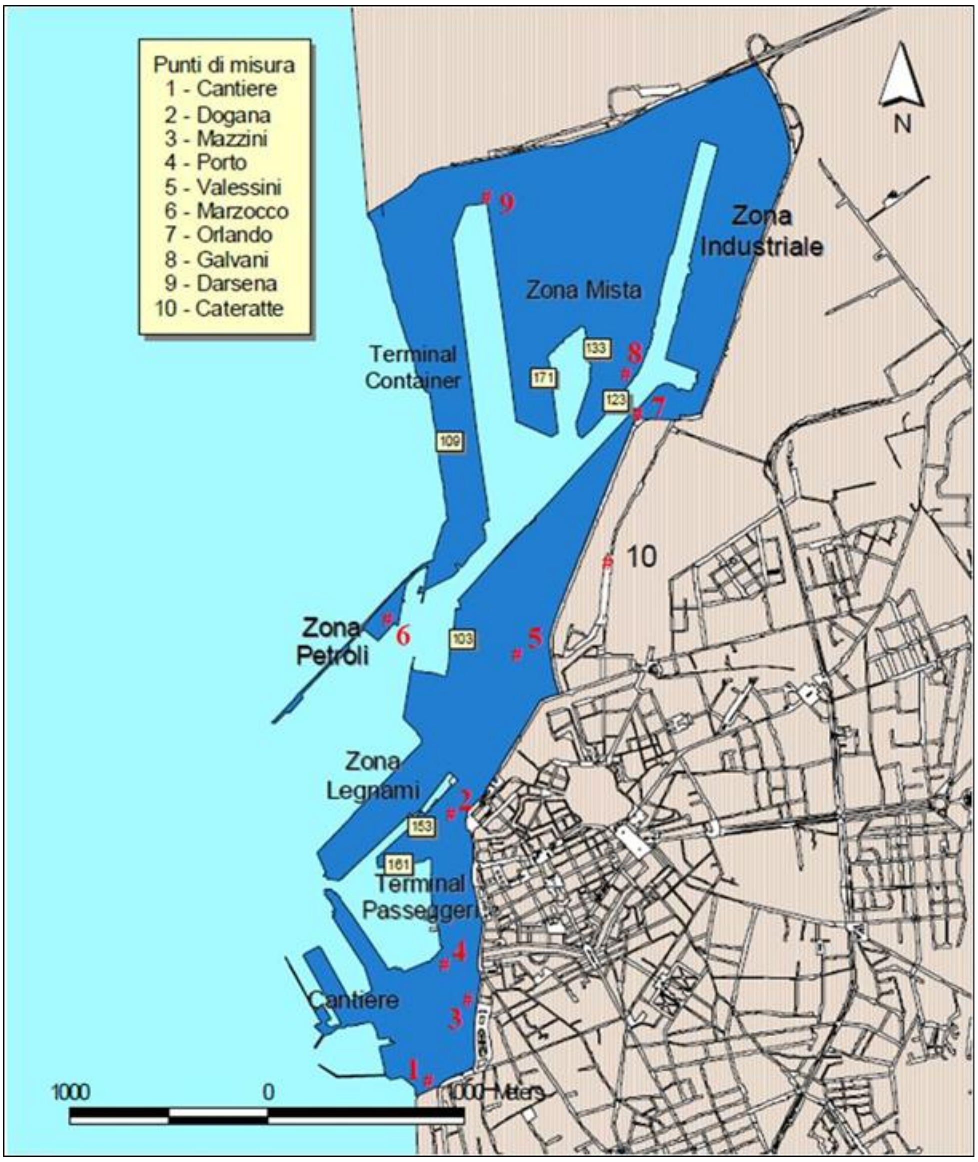

Figure 7.2 - Plan of the port of Livorno with sources and measurement points.

Table 7.8 shows the data acquired from instrumental measurements.

Table 7.8 - Results of measurements performed near the port of Livorno.

Measurement point	L_{Aeq} daytime	L_{Aeq} nightime
Darsena	63.0	65.0
Orlando	61.0	68.0
Galvani	63.0	67.0
Cantiere	52.5	60.0
Dogana	60.0	63.5
Mazzini	61.0	67.5
Marzocco	56.0	58.5
Porto	53.5	61.5
Cateratte	60.5	69.5
Valessini	54.0	53.0
Average	**59.4**	**63.5**

The Via Orlando station is located on a road subject to heavy traffic, so the statistical determination of the background noise can be underestimated, and consequently the port contribution is overestimated. Following this observation, this station was the subject of controlled measures. On these occasions the noises associated with the passage of some ships were measured, during observable pauses of the present road traffic; the average value of L_{Aeq} is 57.5 dB (A).

Compared to the planimetry of the measurements carried out in 1999, the port of Livorno has undergone some transformations, including the opening of the Molo Italia and the start of works for the construction of the Darsena Europa through reclaimed tanks. Figure 7.3 shows the new infrastructural configuration.

Figure 7.3: Aerial view of the port of Livorno: in the foreground the Molo Italia, mainly dedicated to the movement of break bulk goods and passengers; in the background the fill tanks of the future Darsena Europa.

In 2007, acoustic surveys were carried out concerning the construction sites for the infrastructure of the tourist landing place within the commercial port of Livorno.

The surveys, carried out within the area surrounding the shipyards, had the results reported in table 7.9.

Table 7.9 - Table of acoustic surveys in the Livorno shipyards area – 2007

ZONA	SIGLA	DATA INIZIO	ORA INIZIO	DURATA	LEQ	LDAY	LEVE	LNIGHT	LDEN
Stazione Marittima	F4	03/09/2007	10:57:06	12' 30"	58,7	55,0	49,5	51,0	58,0
Mediceo	T	20/09/2007	10:42:37	24 h	0,0	67,3	58,7	53,5	66,1
Mediceo	T7	20/09/2007	12:58:14	11' 40"	55,1	62,5	53,9	48,7	61,3
Mediceo	T1	20/09/2007	11:03:41	15' 58"	64,3	70,1	61,5	56,3	68,9
Mediceo	T4	20/09/2007	12:08:23	11' 49"	54,5	59,5	50,9	45,7	58,3
Mediceo	T6	20/09/2007	12:42:54	11' 04"	62,0	69,3	60,7	55,5	68,1
Mediceo	T5	20/09/2007	12:28:27	11' 36"	63,1	71,5	62,9	57,7	70,3
Quattro mori	R	17/09/2007	11:03:05	24 h	0,0	70,6	69,5	65,8	73,4
Quattro mori	R1	17/09/2007	11:08:37	12' 20"	65,9	66,5	65,4	61,7	69,3
Quattro mori	R2	17/09/2007	11:27:21	11' 14"	70,5	70,6	69,5	65,8	73,4
Quattro mori	R3	17/09/2007	11:45:49	15' 13"	73,3	72,8	71,7	68,0	75,6
Cialdini-Mazzini	S	18/09/2007	14:34:24	24 h	0,0	73,7	71,9	67,7	75,7
Cialdini-Mazzini	S4	18/09/2007	17:04:29	10' 50"	74,1	74,0	72,2	68,0	76,0
Cialdini-Mazzini	S3	18/09/2007	16:49:37	10' 45"	74,1	73,6	71,8	67,6	75,6
Cialdini-Mazzini	S2	18/09/2007	16:31:34	13' 45"	74,9	75,7	73,9	69,7	77,7
Cialdini-Mazzini	S1	18/09/2007	16:17:10	10' 56"	73,6	73,9	72,1	67,9	75,9
Alto fondale	H1	05/09/2007	16:36:49	10' 19"	59,7	61,2	45,9	48,0	60,0
Alto fondale	H2	05/09/2007	16:53:30	10' 14"	57,3	58,8	43,5	45,6	57,6
Mediceo	T2	20/09/2007	11:23:14	19' 26"	62,3	63,2	54,6	49,4	62,0
Mediceo	T3	20/09/2007	11:53:49	11' 59"	69,3	70,8	62,2	57,0	69,6
Piloti	U	24/09/2007	15:34:42	24 h	0,0	56,5	55,7	49,2	58,0
Piloti	U1	25/09/2007	09:41:52	11' 10"	62,9	56,9	56,1	49,6	58,4
Piloti	U2	25/09/2007	09:56:47	10' 20"	63,1	63,3	62,5	56,0	64,8
Piloti	U3	25/09/2007	10:13:53	10' 32"	58,1	52,7	51,9	45,4	54,2
Carenaggio-Anelli	Carenaggio	03/10/2007	15:27:23	24 h	63,0	64,3	61,4	59,5	66,9
Carenaggio	Portur 1	03/10/2007	15:35:24	10' 33"	54,3	55,4	52,5	50,6	58,0
Carenaggio	Portur 2	03/10/2007	15:49:14	10' 24"	55,9	56,8	53,9	52,0	59,4
Carenaggio	Portur 3	03/10/2007	16:01:41	10' 07"	64,8	65,1	62,2	60,3	67,7
Andana Anelli	Portur 4	03/10/2007	16:14:30	10' 06"	56,0	57,8	54,9	53,0	60,4
Andana Anelli	Portur 5	03/10/2007	16:26:49	10' 41"	57,8	58,3	55,4	53,5	60,9
Mediceo sud	Mediceo su	10/10/2007	12:38:35	24 h	60,5	62,1	59,3	55,1	63,5
Mediceo sud	Portur 6	10/10/2007	17:11:57	11' 46"	60,5	61,9	59,1	54,9	63,3
Mediceo sud	Portur 7	10/10/2007	17:27:09	11' 11"	63,1	62,9	60,1	55,9	64,3
Mediceo sud	Portur 8	10/10/2007	17:42:05	11' 22"	64,0	62,9	60,1	55,9	64,3
Azimut	Azimut	11/10/2007	13:30:20	24 h	59,1	61,2	51,6	47,3	59,9
Azimut	Portur 9	12/10/2007	11:23:43	11' 25"	54,0	56,6	47,0	42,7	55,3
Azimut	Portur 10	12/10/2007	11:41:16	10' 35"	60,6	63,2	53,6	49,3	61,9
Azimut	Portur 11	12/10/2007	12:02:49	10' 41"	56,8	59,3	49,7	45,4	58,0
Azimut	Portur 12	12/10/2007	12:39:24	13' 33"	74,1	76,5	66,9	62,6	75,2
Azimut	Portur 13	12/10/2007	13:02:28	14' 24"	59,9	62,2	52,6	48,3	60,9
Nautico	Portur 14	16/10/2007	11:39:35	11' 21"	57,9	0,0	0,0	0,0	0,0
Nautico	Portur 15	16/10/2007	11:52:10	11' 00"	58,8	0,0	0,0	0,0	0,0
Nautico	Portur 16	16/10/2007	12:04:28	10' 16"	57,8	0,0	0,0	0,0	0,0
Nautico	Portur 17	16/10/2007	12:16:44	12' 30"	68,9	0,0	0,0	0,0	0,0

As can be seen from the map (Figure 7.4), the area subject to measurement is rather limited in the port area of Livorno:

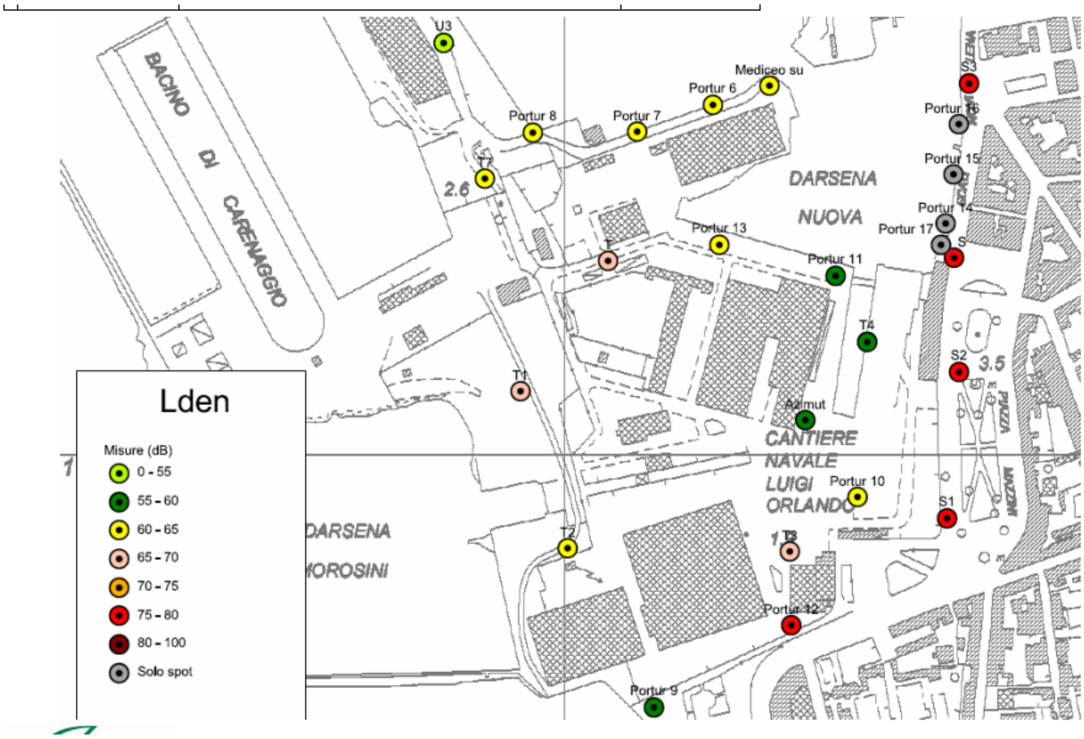

Figure 7.4: Area subject to acoustic detection, port of Livorno, 2007

The area is characterised by the high proximity to the urban fabric and therefore by the higher acoustic impact on the city.

Port of Messina

The port of Messina has a characteristic sickle shape where the longest branch is bordered by the city with residential and commercial buildings, while the final arch is reserved for the Navy and shipbuilding without the presence of buildings intended for residential use. The port area is separated from the buildings by a road of great communication. This road allows, in addition to urban roads, also access to the boarding area of the State Railways and private companies. The borders of the port area are about 30 m from the quay, while the houses, due to the presence of the arterial road, are located at a distance from the borders of the port area between 70 and 90 m.

The port of Messina, which plays a fundamental role as the main link between Sicily and Calabria, is characterised mainly by commercial and passenger traffic which is mainly carried out using ferries that transport cars, trains and trucks. The port also has a fair amount of activity due to the passage of merchant and cruise ships. Detached from the purely port area, and a few kilometres from it, there is a zone used for the connection with Calabria Region by ferries of private companies. This area of limited dimensions is integrated in the urban context so that the movement of ships takes place a few tens of meters from the houses. Even in this case, however, the buildings are separated from the belt intended for embarking and disembarking vehicles from a wide road with heavy traffic.

Four measurement stations representing the situations considered most significant for the purpose of assessing the noise impact of the entire port area were identified. It should be noted that the houses are located near the measurement sites, since they are located along roads with high vehicular traffic (increased however by the influx of vehicles and boats). Monitored measurements were performed due to the constant difficulty of eliminating the contribution of road traffic from port sources. The individual surveys lasted 60 minutes. The plot of the port of Messina are shown in Figure 7.5 and a description of the measurement sites identified is following described.

Site no. 1 (Viale della Libertà, n. 34).

Sources of port noise: three piers for private car ferries.

The nearest houses are located about 45 meters from the measuring point and about 60 meters from the quay. The exact site of the measure was chosen to eliminate from the measure, as far as possible, the influence of city vehicular traffic and therefore the detected noise levels are mainly attributable to the transit of vehicles, both during disembarkation and during embarkation, coming or going to the pier identified with number 1, as well as to port operators who use whistles or shout loudly during these manoeuvres.

Figure 7.5: Plan of the port of Messina.

Site no. 2 (Via V. Emanuele II -Hotel Jolly).

Sources of port noise: pier for the docking of private hydrofoils and transit of all ships, both inbound and outbound from the port of Messina. The nearest buildings (one hotel and private houses) are located at about 27.5 meters from the measuring point and about 29 meters from the quay. The average height of the houses, compared to the street level, is about 16 meters. The microphone was placed at a distance of about 1.5 meters from the dock. The distances of the dock from the measuring point is about 13 meters; the distance from the station to the point of passage of the ships is a hundred meters.

Site no. 3 (harbor wall - Viale Luigi Rizzo).

Port noise sources:

- entry and / or exit of vehicles passing through the use of N.G.I. (Navigazione Generale Italiana) and of MERIDIANA LINES;
- dockside of Ferrovie dello Stato (Italian Rail company)
- access lanes to Ferrovie dello Stato

In general, the station allows the detection of the noise produced by passenger traffic (predominant activity of the port of Messina).

The nearest houses are located at about 80/90 meters from the measuring point and at about 120 meters from the quay. The average height of the same, compared to the road surface, is equal to about 19/20 meters.

Site no. 4 (inside the port area, about 5.30 meters from the boundary wall).

Port noise sources:

- Maritime station of the FF.SS. (about 40 m);
- docking platform of the FF.SS. (about 30 m);
- access lanes to the FF.SS. (at about 8 m).

The nearest houses are located about 60/70 meters away from the measuring point and about 120 meters from the quay. The average height of the same, compared to the road surface, is equal to about 19/20 meters.

Measurements Results

The following tables summarize the results of the measurements performed. Table 7.10 shows the average results for each site and the sources investigated. Table 7.11 shows the average L_{Aeq} values calculated for all sites relative to the two day and night reference periods.

Table 7.10 – Results from the measurements performed on Messina Port.

Site	Date	Time	Period	L_{Aeq}	Sources
1	21/08/2000	18:38-19:38	daytime	72.3	Ferries- Arrivals and departures
	21/08/2000	23:34-00:22	nightime	73.2	Ferries- Arrivals and departures
	22/08/2000	10:17-11:17	daytime	70.7	Ferries- Arrivals and departures
2	22/08/2000	08:52-09:52	daytime	65.1	Ferries- Arrivals and departures /Boats passage
	22/08/2000	17:07-18:07	daytime	63.6	Boats passage
	23/08/2000	22:04-23:04	nightime	62.5	Boats passage
3	22/08/2000	18:08-19:04	daytime	67.1	Ferries and hydrofoil- Arrivals and departures
	23/08/2000	08:27-09:27	daytime	68.8	Ferries and hydrofoil- Arrivals and departures
	23/08/2000	23:29-00:29	nightime	67.9	Ferries- Arrivals and departures
4	23/08/2000	17:32-18:32	daytime	67.1	Ferries and hydrofoil- Arrivals and departures
	23/10/2000	23:25-00:25	nightime	62.8	Ferries- Arrivals and departures

Table 7.11 - Average values of the measurements performed on Messina Port.

Reference period	L_{Aeq}				
	Site 1	Site 2	Site 3	Site 4	Average
Daytime	71.6	64.4	68.0	67.1	68.6
Nightime	73.2	62.5	67.9	62.8	68.9

It is commonly possible to observe that the noise produced by the port activity is lower than 70 dB (A) and it is essentially due to the movement of the vehicles in the boarding and disembarkation operations, as well as to the approach of the same to the parking areas before said operations. Only near the measurement site n. 1, where sampling was carried out just near the embarkation and / or landing docks, values of an equivalent level higher than 70 dB (A) were found, both during the day and night reference period.

For the purposes of estimating the acoustic impact determined by port sources against neighbouring receptors, it is important to note that these are affected more by the noise produced by vehicular traffic than by that related to port activities.

7.2 Greece

The port of Patras is the gateway of Greece to Europe and it is one of the most modern ports in the Mediterranean, offering modern port infrastructure, a modern cruise terminal and professional quality of hospitality services in high health and safety standards. The Patras port significantly contributes in the local economy, creating 2,504 jobs through the directly dependent businesses, 1,013 direct jobs with revenue 12.2 million Euros and 1,491 indirect jobs with revenue approximately 9.2 million Euros.

The port of Patras is connected with regular service to the ports of Brindisi, Ancona, Venezia, Bari, Genova, Ravenna, Trieste, Bar, Salerno, Catania.

Northern Passenger Port

The Northern Port of Patras has four main piers and wharfs of approximately 3.000 m total length and 8.5-10.5 m width. The Port capacity can afford mercantile ships up to 25,000 register tons and passenger ferry ships up to 16,000 register tons and up to 330 meters length.

Commercial Port

Patras Port Authority has in the North Port facilities, machinery and staff that can serve cargo transit. Moreover, it has an open storage area for deposition of general cargo. The operation of the customs service allows the traffic of imported and exported merchandise.

Furthermore, it has 3 weighbridges (two in the South Port and one in the North) for weight control of vehicles and weighing of cargoes.

All services provided by O.L.PA. to port facility users are classified in 4 tariff categories, as set out by decision 48058/EGDEKO (Special Secretariat for Public Enterprises and Organizations) 1680.

Southern Passenger Port

On July 11th 2011 the new South Port of Patras has become operable for the itineraries between Patras and Italy.

The Southern Passenger Port of Patras has a platform of 992 m total length, built with caissons of reinforced concrete in a zigzag alignment. It consists of 4 dock stations and it has 15 docks, 11 of which can be used for mooring by stern and 4 can be used for side-mooring. In addition, the Southern Port has breakwaters of 1.236 m total length, built with caissons of reinforced concrete.

Marina

At the Northern Port of Patras there is a Marina which can serve up to 450 boats (depending on their size). The marina has 3 small basins (of 3.5 meters depth), 8 permanent piers and 3 floating piers.

At the south basin there is a wharf and 3 wooden floating piers (68 meters long each), at the middle basin there are 6 wooden permanent piers (44 meters long each) and at the north basin there are 2 permanent basins.

The marina is protected by breakwaters 620 meters long (towards west) and 52 meters long (towards north).

The overall traffic from 2003 can be seen in tables 7.12 and 7.13 and in figure 7.6:

Table 7.12 – Patras passenger and Vehicle Traffic / Traffic data to/from foreign destinations

Year	Passengers	Trucks	Unaccompanied	Buses	Vehicles	Motorcycles
2010	879,314	170,547	54,319	4,135	151,223	15,094
2011	748,029	145,843	51,866	3,445	135,925	8,287
2012	508,827	127,971	47,986	2,069	89,555	4,951
2013	541,719	123,661	57,804	2,240	100,902	5,458
2014	555,453	122,139	58,426	2,737	102,161	5,905

Table 7.12 – Patras traffic to/from local destinations.

Year	Passengers	Trucks	Unaccompanied	Buses	Vehicles	Motorcycles
2010	425,503	15,075	10	3,109	65,227	8,133
2011	413,202	12,632	-	2,985	64,031	7,959
2012	339,590	10,107	59	2,765	55,653	6,000
2013	182,272	3,683	12	1,593	27,753	3,911

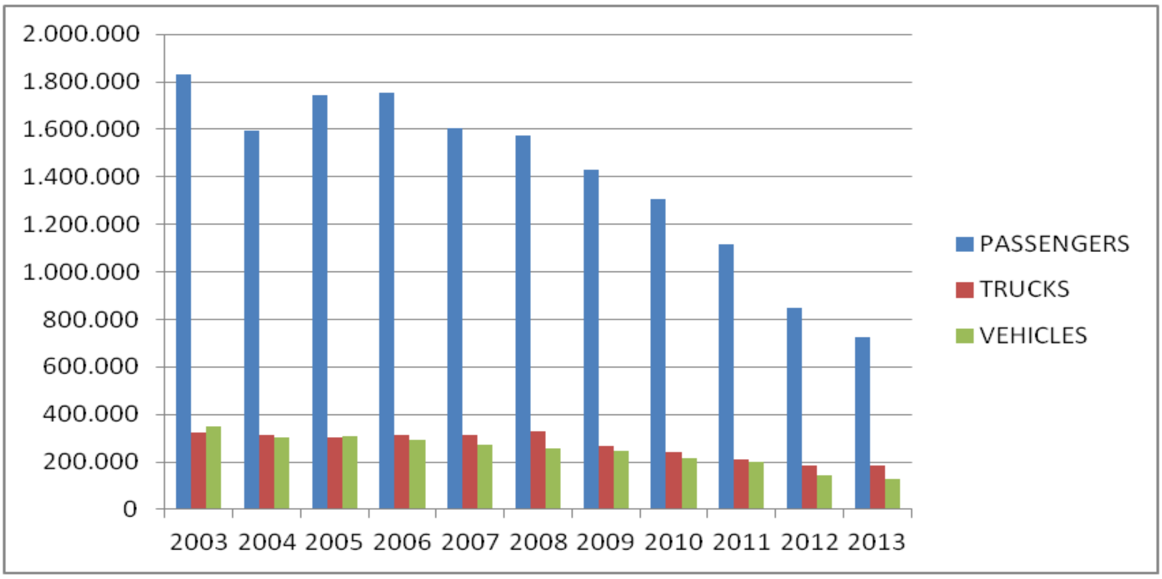

Figure 7.6: Traffic in the Port of Patras (2003-2013).

Noise Measurements

Introduction

The premises of the building of Municipal Enterprise of Development of Patras SA (ADEP SA) which made noise level measurements are the external spaces and spaces on the first floor of the main building, located on the street El. Venizelou 38 & Solomou.

Inside the first floor of the building there are about 15 jobs spread over seven sites. To achieve a realistic visualization of the noise level in each of them, three sets of measurements were executed.

The main road that passes in front of the building is the main source of noise pollution in the area, as there were measured sound levels exceeding 70 dB.

Inside the building, based on the measurements made, high noise levels were observed in virtually all workplaces, whether open offices or enclosed spaces. Specifically, the measured noise levels ranging outside the boundary acoustic comfort even for building classified as Class II "Normal Acoustic Comfort" in accordance with Article 12 of Greek building code (Government Gazette 59 / A / 2.3.1989).

In existing frames and glass a damage occurred due to poor maintenance or original material failure. Specifically, the humidity presence was observed inside the glass; besides, aluminum frames do not implement appropriate security systems.

Measurement Process

For the process of noise measurements, the following electronic equipment was used:

- Amplifier: Focusrite Scarlett 18i20.
- External audio amplifier with 18 inputs and 20 outputs connected to the USB port on the computer that performs the statistical analysis of the measurements.
- Ichometro: NTi AUDIO XL2.
- Handheld Audio Analyzer with integrated high-precision microphone with linear behavior range of sounds from 15 to 20 kHz.
- Processing Software Measurement: SignalScope Pro (Faber Acoustical).
- Multi-channel dynamic signal analyzer and data entry platform software in MacOS X.

Measurement Methodology

During the first series of internal measurements (figure 7.7), the air conditioning units of the building were turned off and the windows were open. At the second set of measurements, the air conditioning units of the building was again turned off while the windows remained closed. In the third and final set of measurements the air conditioning units were put into operation and the windows were closed.

In each work position and for each measurement series as previously mentioned, the value of LAeq measured for a period of two minutes. During the course of the measurements any job was vacant in order to avoid errors in the assessment of the level of external noise, while the doors of the rooms, the cabinets and the courtroom remained closed to simulate the typical working day in each case. The microphone and sound level meter were adjusted before each series of measurements.

For an accurate measurement of external noise from passing vehicles from the road of Eleftherios Venizelos road connecting Patras Port to the Perimeter Road and passing in front of the building of ADEP SA, three sets of measurements were executed.

The first measurement took place in the port wharf at the time where a passenger ship disembarked passengers cars and MD trucks. The second measurement was carried out at the entrance of the port leading to the Eleftherios Venizelos street, namely at the intersection of Eleftherios Venizelos street and Dymaion Coast, while the third noise measurement was carried out on the sidewalk and the courtyard of the building ADEP SA.

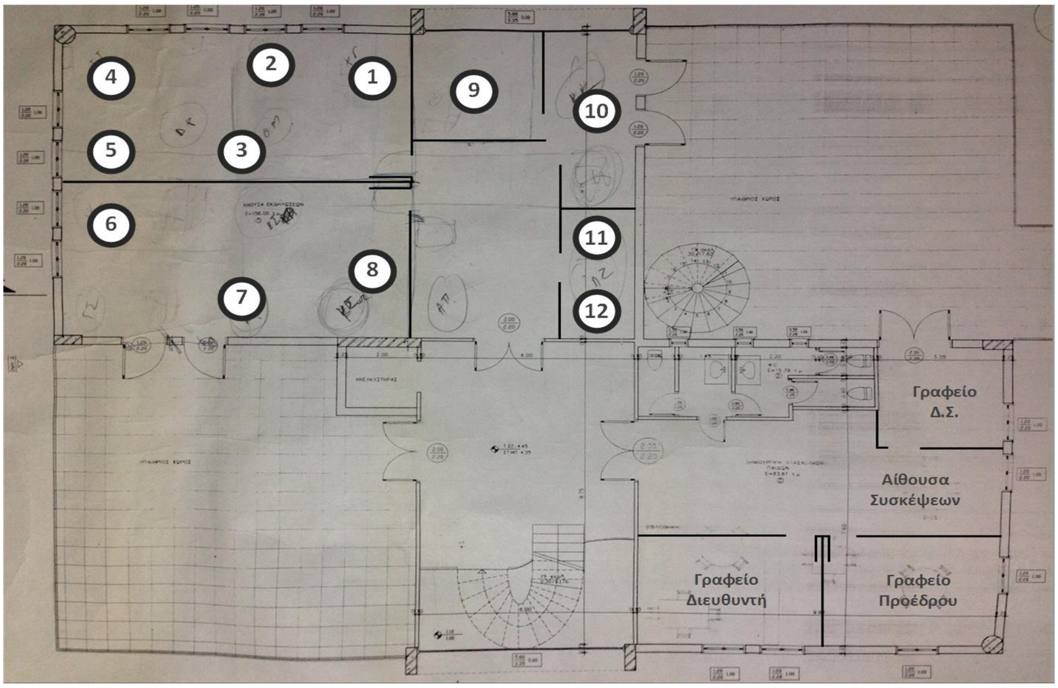

Figure 7.7: Measurement points on the first floor of the building ADEP SA.

The noise measurements made in internal and external areas of the building ADEP SA, according to the methodology described in the preceding paragraphs, revealed the results reported in tables 7.13, 7.14, 7.15 and 7.16.

Table 7.13 - Interior Noise Measurement Services - Series One: Opened windows, A / C Off

Jobs spread	**SPL – L_{Aeq} – dB(A) (min - max)**
1	51.0 – 51.2
2	50.3 – 51.0
3	49.1 – 51.3
4	51.4 – 51.8
5	51.0 – 51.7
Intermediate Average Office Term	50.5 – 51.4
6	48.8 – 50.1
7	48.6 – 51.2
8	48.3 – 50.4
Intermediate Average Office Term	48.6 – 50.6
9	42.6 – 43.1
10	45.8 – 50.6
11	45.0 – 50.0
12	42.1 – 51.0
Director Office	58.4 – 59.7
President Office	53.2 – 53.8
Administrative Council Office	47.9 – 51.1
Conference room	45.3 – 47.7

Table 7.14 - Interior Noise Measurement Services - Second Series: Closed windows, A / C Off

Jobs spread	SPL – L_{Aeq} – dB(A) (min - max)
1	44.9 – 45.1
2	44.6 – 44.9
3	44.1 – 44.5
4	44.3 – 44.7
5	44.3 – 44.8
Intermediate Average Office Term	44.4 – 44.8
6	44.2 – 45.9
7	44.8 – 45.7
8	44.6 – 45.8
Intermediate Average Office Term	44.3 – 45.8
9	38.7 - 39.9
10	45.1 – 46.2
11	45.0 – 45.1
12	45.6 – 45.7
Director Office	42.8 – 43.8
President Office	43.2 - 44.1
Administrative Council Office	43.0 – 43.4
Conference room	39.5 – 42.6

Table 7.15 - Interior Noise Measurement Services - Range Tuesday: Closed windows, A / C Enabled

Jobs spread	SPL – L_{Aeq} – dB(A) (min - max)
1	47.6 – 48.0
2	47.5 – 47.8
3	46.9 – 47.3
4	47.6 – 47.4
5	47.6 – 47.3
Intermediate Average Office Term	47.4 – 47.6
6	47.1 – 47.9
7	47.3 – 47.8
8	47.5 – 47.9
Intermediate Average Office Term	47.5 – 47.9
9	40.9 - 41.1
10	47.1 – 47.7
11	47.4 – 47.9
12	47.6 – 47.9
Director Office	45.4 - 45.6
President Office	45.9 - 46.3
Administrative Council Office	46.1 – 47.0
Conference room	41.0 – 41.3

Table 7.16 - External Noise Measurement Services - Courtyard Building of Development Municipal Enterprise of Patras SA OTA (ADEP SA)

Courtyard building ADEP SA		**SPL – L_{Aeq} – dB(A) (min – max)**
Site 1	0-5 min	65.0 – 72.5
	6-10 min	61.3 – 73.4
	11-15 min	60.6 – 69.7
Intermediate Average		62.3 – 71.8
Site 2	0-5 min	66.1 – 71.0
	6-10 min	60.2 – 69.6
	11-15 min	59.3 – 76.8
Intermediate Average		61.8 – 73.4

7.3 SPAIN

Introduction

The only noise measurement campaign that has been carried out is the one detailed in the noise map of Melilla Port. The measurement campaign consists of 10 long-term sampling points and 9 short-term sampling points.

The following sections describe the results obtained.

Long term measurements

The location of the sampling points are shown in figure 7.8, while the results are reported in table 7.17 and figure 7.9.

Figure 7.8: Location of long term measurement points for Melilla Port.

Table 7.17 – Results of long term Melilla measurement campaign.

Point	Location	Start	End	Time	Height (m)	Type of noise	L_{Aeqd} (dBA)	L_{Aeqe} (dBA)	L_{Aeqn} (dBA)
1	Marina	14/07/2017 12:27 Friday	17/07/2017 12.37 Monday	3 days	4.5	Leisure	63.3	60.1	72.0
2	Marina	14/07/2017 12:39 Friday	16/07/2017 19.59 Sunday	2 days	4.5	Leisure- ferrys	59.6	61.5	62.4
3	Ferry terminal	05/07/2017 11:52 Wednesday	07/07/2017 12:32 Friday	2 days	4.5	Road Traficc - ferrys	63.9	65.3	60.7
4	Ferry terminal	05/07/2017 12:15 Wednesday	07/07/2017 12:45 Friday	2 days	4.5	Road Traficc	65.6	63.5	59.4
5	Old Town	04/07/2017 10:21 Tuesday	05/07/2017 11:01 Wednesday	1 days	6.0	Road Traficc - ferrys	58.1	56.4	53.4
6	Fishing Dock	04/07/2017 10:47 Tuesday	05/07/2017 11:22 Wednesday	1 days	4.5	Road Traficc	65.1	65.1	60.3
7	“Florentina”	12/07/2017 12:09 Wednesday	14/07/2017 11:49 Friday	2 days	3.0	Road Traficc	68.8	69.8	64.3
8	Containers	10/07/2017 10:57 Monday	12/07/2017 11:37 Wednesday	2 days	4.5	Containers Operations	59.8	59.5	57.9
9	Quay “Espigón”	12/07/2017 12:29 Wednesday	14/07/2017 11:54 Friday	2 days	6.0	Indsutrial Noise - ferrys	65.4	67.3	63.7
10	Containers	10/07/2017 11:16 Monday	12/07/2017 11:51 Wednesday	2 days	4.5	Industrial Noise	68.1	65.3	61.7

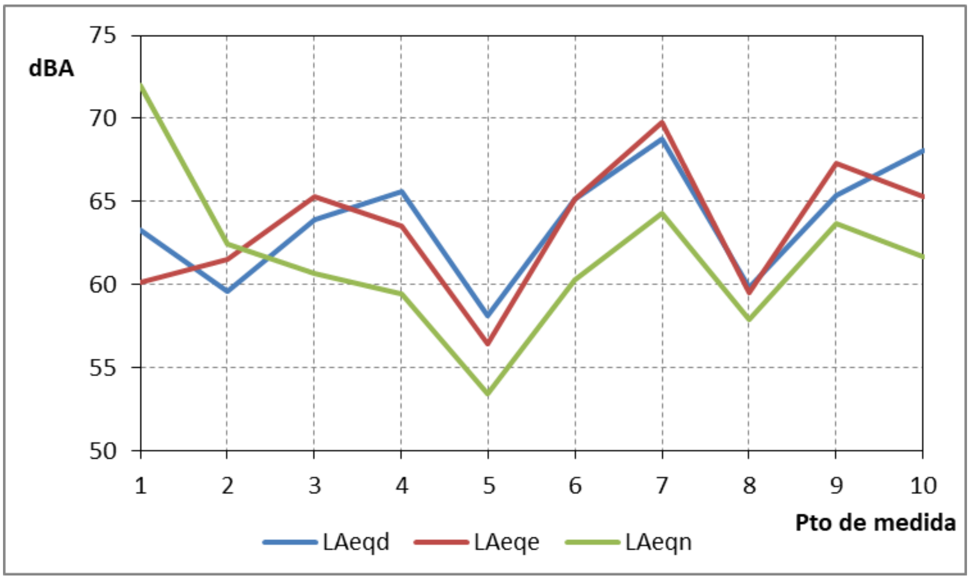

Figure 7.9: Results on the different measurement points.

Observations:

- Point 1: there are significantly high levels between 01:00 and 04:30 h, corresponding to the early morning hours of Friday and Saturday, with average levels in the night period above the average levels in the day period. At dawn on Sunday there is a high reduction in levels, which are significantly lowered after 2:00.
- Point 2: at this point there are high levels coinciding with the ferries operations and maneuvers, a situation that overlaps the nocturnal leisure activity.
- Point 3: at this point there are high levels derived from the activity of the Maritime Station throughout the morning (08:00 to 14:30), as well as an increase in levels, prior to the departure of the ferry docked at the dock “Ribera I ", between 22:00 and 24:00.
- Point 4: at this point the traffic noise stands out practically constant throughout the day (08:00 a.m. to 11:00 p.m.).
- Point 5: the variation of levels in this point is similar to that obtained in point 3, with high levels derived from the activity of the Ferry terminal throughout the morning (08:00 a.m. to 02:30 p.m.), as well as an increase in levels, prior to the departure of the ferry docked at the "Ribera I" wharf, between 22:00 and 24:00.
- Point 6: at this point high levels are maintained throughout the day, from 08:00 to 23:00 h.
- Point 7: this point is located in the roundabout before the check point to the port and high levels are registered throughout the day, from 06:00 to 24:00 h.
- Point 8: variable levels are observed during the day, with a significant decrease during the night, from 00:30 to 07:30 h.
- Point 9: at this point, located next to the pier "Espigón", it is possible to see intervals with quite constant levels, possibly due to the presence of a ferry on the dock, together with periods in which the levels suffer strong variations. It highlights the fact that during the night the levels are not reduced.
- Point 10: the noise at this point is variable, with a pattern that does not exactly match the day-night cycle and with a significant variation between one day and another, probably due to the performance of some activity that takes place in a specific day.

The measurement campaign does not reflect the operating hours of the ferries. Likewise, the activities carried out in the port that may affect the results of the noise measurements are not reflected either.

Short term measurements

The location of the sampling points is shown in figures 7.10 – 7.11, while the results are reported in tables 7.18 – 7.19.

Figure 7.10: Location of short term measurement points for Melilla Port - 1.

Figure 7.11: Location of short term measurement points for Melilla Port - 2.

Table 7.18 – Results of Melilla short term measurement campaign - 1.

Point	Location	Start	Time	Height (m)	Type of noise	L_{Aeq} (dBA)
11	Quay "Espigón"	04/07/2017 20:18 Tuesday	15 min	1,5	Ferry Engine (Volcán de Tinamar)	63,4
12	Quay "Espigón"	04/07/2017 20:35 Tuesday	15 min	1,5		61,9
13	Quay "Ribera II "	04/07/2017 20:58 Tuesday	15 min	1,5	Ferry Engine (Pinar del Río)	65,3
14	Quay "Ribera II "	04/07/2017 21:17 Tuesday	15 min	1,5		68,1
15	Quay "Ribera I "	04/07/2017 21:34 Tuesday	45 min	1,5	Ferry Engine & Port Operations (Fortuny)	74,7
16	Quay "Ribera I "	04/07/2017 22:22 Tuesday	15 min	1,5	Ferry Engine (Fortuny)	78,8

Table7.19 – Results of Melilla short term measurement campaign - 2.

Point	Location	Start	Time	Height (m)	Type of noise	L_{Aeq} (dBA)
17	Garages	05/07/2017 13:07 Wednesday	15 min	1,5	Concrete Plant works	70,8
18	Bivalve Treatment Plant	05/07/2017 13:24 Wednesday	15 min	1,5	Concrete Plant works & Road Traffic	72,1
19	Roundabout	05/07/2017 13:41 Wednesday	15 min	1,5	Road Traffic	65,4

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Project information

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