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ANCHOR Life

Advanced Noise Control strategies in HarbOuR

Ex-ante assessment on noise levels

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1. Introduction

The Anchor LIFE project deals with the incentivization of more sustainable operations in ports, with particular attention paid to the acoustic pollution. In this respect, it foresees an ex ante assessment of noise levels in the port of Livorno, before the Figures of Merit are tested in this seaport. For doing this, an acoustic mapping of the port of Livorno has been used to verify current levels of noise emissions made by the port. This acoustic mapping is referred to the below mentioned sources:

- Naval sources;
- Port sources;
- Industrial sources;
- Road sources;
- Railway sources.

For each source of noise was created a map of loudness contours, according to both the European indicators L DEN / L NIGHT.

Moreover, noise maps were calculated on the more exposed facade relating to the reference periods of day and night.

Noise maps are made by I-POOL company by developing an acoustic model on the predictive calculation software SoundPLAN 8.1, which allows the acoustic modeling in accordance with the standards adopted at national and international levels for noise calculation, thanks to the ray tracing method. The mappings are financed by the Mon Acumen project.

2. The acoustic model

The acoustic model developed is able to calculate the noise propagation emitted from each of the sources taken into consideration.

The propagation is calculated in the entire area surrounding each source.

The result of the calculation in one point of space is the overall sound level, due to the contributions of all the noise sources.

The development of an acoustic model is carried out by following the following steps:

- Definition of the calculation area;
- Geographical characterization of the territory;
- Definition and location of sources and receptors;
- Acoustic characterization of sources;
- Execution of the calculation;

- Validation of the acoustic model.

In order to define the calculation area, taking advantage of previous mapping work of the acoustics of the Port of Livorno and the surrounding areas, a first simulation of the model was carried out considering all the noise sources attributable to port activities, but in the absence of the buildings.

The execution of this work will involve an update of the previous model for the definition of the calculation area, in particular new noise sources will be added, the first step was identifying an area presumably larger than the definitive one.

For the geographical characterization of the territory, the necessary cartographic data were found:

- The definition of the digital terrain model (DTM), produced from the available cartography;
- The definition of the acoustic characteristics of the ground cover;
- The building has been updated through inspections;
- Performing the calculation.

The calculation settings adopted to develop the acoustic model and perform the calculation of the propagation to the receptor, are shown in the following table:

CALCULATION SETTINGS

Reflection order	1
Max search radius (m)	500
Max distance of reflections from receptor (m)	500
Max distance of reflections from source (m)	100
Grid spacing (m)	10
Reception points for facade level calculation (FNM)	1 in the center of each facade for each floor
Distance from the facade for FNM (m)	1.0
Height for FNM (m)	1.5
Height of upper floors for FNM (m)	3.0
weighted dB	dB(A)
Industrial noise standard	ISO 9613-2:1996 and CNOSSOS
Standard road noise	NMPB 2008 and CNOSSOS

Once all the input parameters to the acoustic model have been defined and the calculation has been made, the results obtained are used to create georeferenced maps of the estimated sound levels according to the various indicators and the relative exposure maps. To create the maps it is useful make use of a GIS tool, which becomes indispensable for complex and large geographic scenarios. The Open Source QGIS platform was used for this work.

3. Naval sources: performed activity

All the noisy activities related to the movement of commercial and passenger ships within the port of Livorno, that is the transit and the docking/undocking phases, have been included within the "naval sources" class.

However, the departure (undocking) and arrival (docking) operations do not involve significant noise and are negligible for the purposes of the model, so they have not been included in the model.

In order to model the noise produced by the movement of the ships, the data relating to the annual departures and arrivals of the vessels for the year 2019 were therefore retrieved for each berth. An analysis was carried out, based on the types of ships, for defining the routes and times of use of equivalent sources to be included in the model. For each type of ship and for each route (internal, outgoing and entering the port) a sound emission line was implemented in the model, based on the cartographic data processed during the mapping phase carried out in the previous mapping work.

The categories of large ships required by the project are:

- Cruise ships;
- Ro-Ro ships;
- Container ships;
- Chemical ships;
- Tankers;
- Ferries.

In accordance with the contract's specifications, in addition to the noise produced by the movement of the ships, the acoustic mapping of the naval sources also includes the noise emission due to the stationing of the ships on the dock, such as ventilation noises, chimneys, engines, etc.

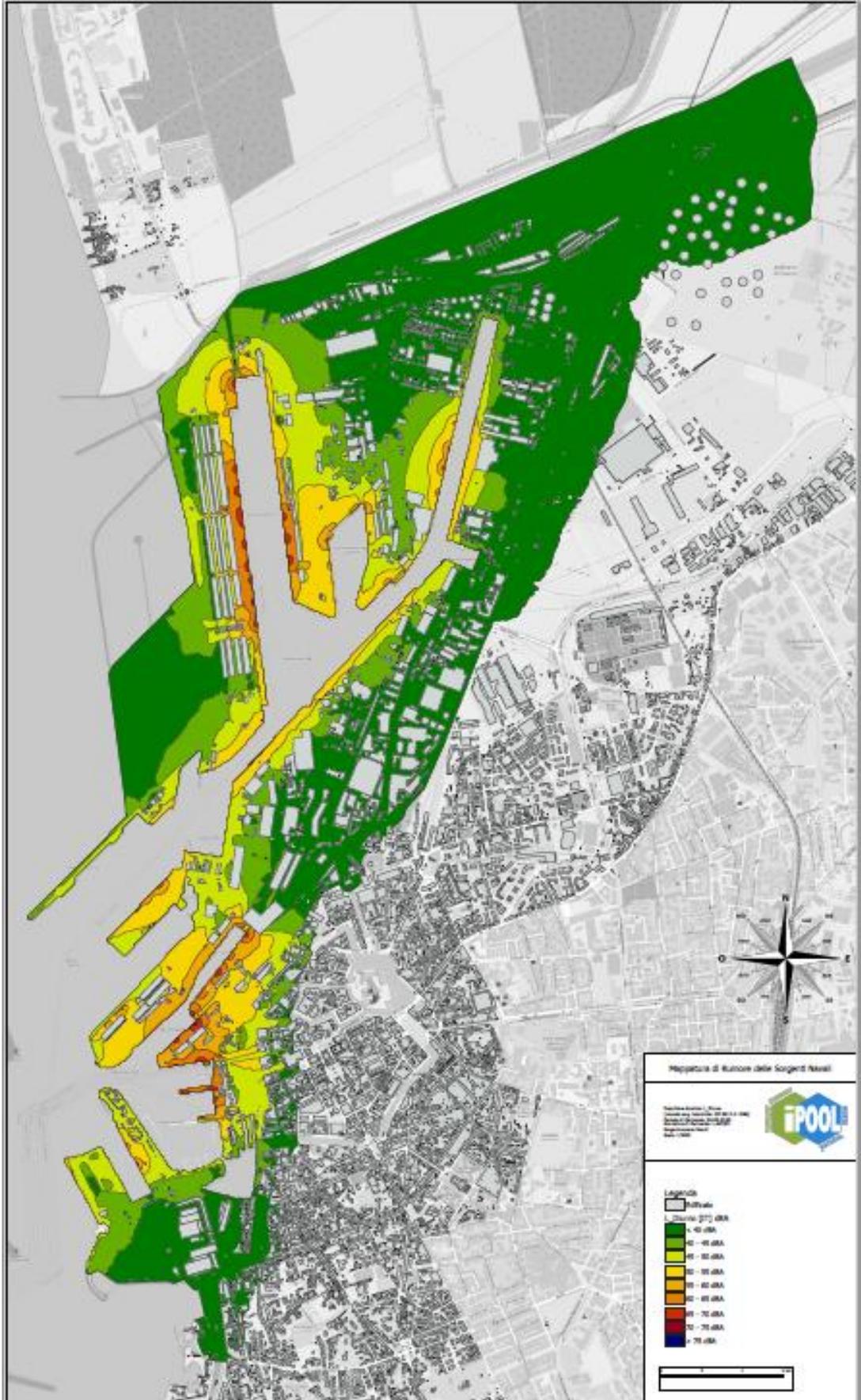
The sources that have been considered for this type of noise are:

- Cruise ships;
- Container ships;
- Ro-Ro ships;
- Ferries

Furthermore, it was decided to integrate the measurement campaigns previously carried out with specific pass-by measurement sessions.

Moreover the boats of the operators and pilots of the port are included in the measurements.

About the naval sources considered for this work, the calibration and validation of the model coincide with what has already been done and published "Fredianelli, L., Nastasi, M., Bernardini, M., Fidecaro, F., & Licitra, G. (2020). Pass-by Characterization of Noise Emitted by Different Categories of Seagoing Ships in Ports. *Sustainability*, 12 (5), 1740.



4. Port sources: performed activity

In this category are considered all industrial noise sources when used in purely port activities such as vehicles and machinery of all kinds, operating in the port area and used in operations of:

- Loading/unloading of freight trains;
- Loading/unloading of ships;
- Ship operations.

To this end, data of the machines' sound power were obtained through the processing of measurements carried out near the sources.

The machinery investigated which are indicated in the contract and present in the port area of Livorno are shown below.

- Ship to shore: Cranes used for unloading and loading the ship.
- RTG: Gantry cranes that move and store containers from above.
- Reach stacker: Vehicle equipped with an arm for moving and storing containers.
- Front lift: Vehicle equipped with an arm to move and store containers vertically.
- Fork lift; Is a powered industrial truck used to lift and move materials over short distances.
- Tractor: Vehicle used for the transport of trailers.
- Scraper: Earth and sand handling machine.
- Dock crane: cranes used for handling various goods and containers.

For each of the sources listed above was evaluated the type of operation in order to characterize the sound emission through two possible approaches: the definition of one point source or the combination of a point source and a linear one.

The need of this division is due to the fact that the moving operations are considered as mobile sound sources.

The operations carried out by the parked vehicle, instead, were modeled through the implementation of a point source.

The times of usage and the position of the industrial sources were obtained from the information provided by the companies responsible for the work activities

Alternatively, where available, information from the companies' noise impact assessments were used.

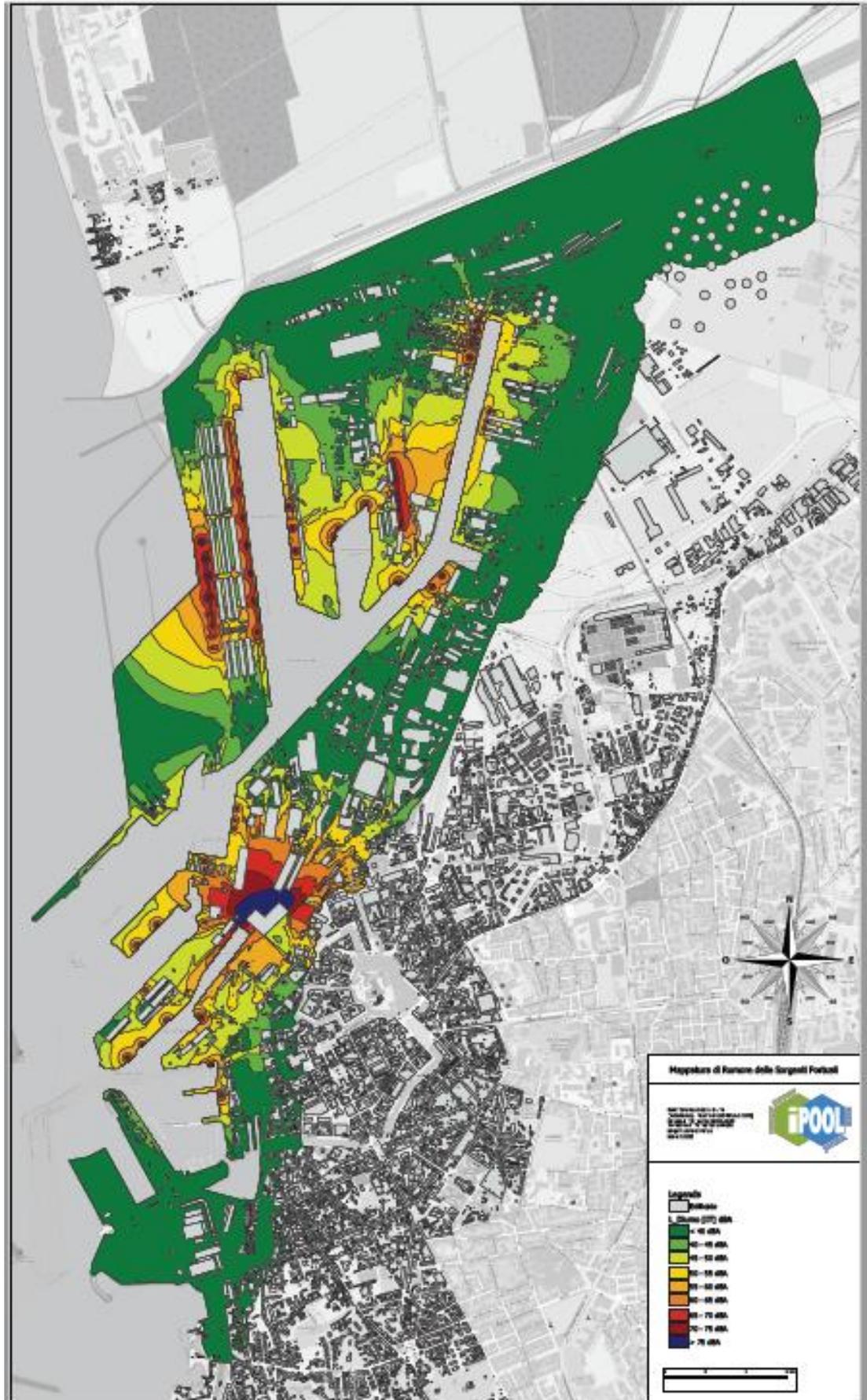
In the absence of both, the times of use and the positions of the machinery already implemented were considered in the previous 2017 acoustic mapping work.



In order to model the noise produced by ship loading / unloading operations, a sound emission area has been implemented in the model for each type of boat and for each dock used as a naval stop.

With regard to the port sources for the following work, the calibration of the model is was considered for the state as reference the previous work.

In particular, some of the measures were used of sound pressure of characterization of the sources to carry out through the software SoundPLAN 8.1 development.



5. Results

The following results were obtained from the calculation of the acoustic model of the railway noise source:

- Levels LAeq during the day and LAeq at night, calculated according to the ISO 9613-2: 1996;
- Levels Lden and Lnight, calculated according to ISO 9613-2: 1996;
- Levels LAeq during the day and LAeq at night, calculated according to CNOSSOS;
- Levels Lden and Lnight, calculated according to CNOSSOS.

For each indicator, the relative map of acoustic contours was created.

Finally, exposure maps were created using the European indicators Lden and Lnight, while noise maps with the facade levels calculated on the most exposed facade were created using the Italian indicators LAeq during the day and LAeq at night.