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CHARACTERIZATION OF PORT NOISE THROUGH A MEAUREMENT CAMPAIGN

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A measurement campaign has been developed for the purpose to identify a survey methodology to be applied to port noise. Until now a specific approach for harbour noise is still missing and this complicates the task of analysing and assessing the acoustic impact of ports on exposed population. The performed study confirmed the need to upgrade the current way. Sources overlapping, directivity ignorance, seasonality and day alternation, sources mix are as many as issues that requires new, more effective, techniques to characterize port noise. With regard to the measures, contemporary close and remote measures are to be made; specific measures designed to characterize the sources are needed (including intensimetric measurements and acoustic cameras); protracted and detailed measurement campaigns are needed. Concerning the port noise modelling, two different approaches are possible. Either every single source and the geometry of the port area are characterized, and then modelled by ray tracing according to the usual method. Or measures are taken on the harbour perimeter, assigning then attempt values to the sound power level of the sources with a "try and correct" technique, until the correct values are determined and the acoustic field is accurately described.
Keywords: port noise, measurement campaign

1. Introduction

Port noise has been long neglected as if, unlike those coming from roads or railways or airports, the generated emissions were not relevant for the quality of life of exposed population. Only recently a certain interest is growing up, mainly because of the increasing reaction of the inhabitants in port cities, who do not tolerate any more annoyance and sleep disturbance coming from harbours.

The limited development of this topic in comparison with the huge amount of studies dedicated to other transportation noise sources is well documented [1], as well as the complexity of the subject [2]. Acoustic impact of ports is the result of a tangled overlapping of noise generated by ships, cranes, upload and download operations, shipyards, trucks and trains, which generate and combine noise along day and night.

Measurements techniques themselves do not appear adequate to this complexity [3]. While the characterization of mobile sources, like the vehicles in their different forms, or of fix sources, like many industrial machineries or plants, has achieved a high level of development and has been adequately standardized, for the harbours the measurements campaigns do not have yet well-established methodology. Besides, the very restricted accessibility of the port areas and the large dimensions of the sources make port noise measurements an even more challenging issue [4].

In this framework, the present study represents an attempt to identify a few key ideas through a survey implemented in the port of Genoa (Italy), which is the first Mediterranean port for number of shipped containers and is close to densely populated urban areas. Those measurements have allowed to pinpoint some critical issues and have suggested further actions in order to better tackle the complexity of port noise.

2. Measurement campaign

As shown in Fig. 1, the survey has addressed diverse sectors of the Port of Genoa. Position A and Position B were set close to the Voltri Terminal Container, in the Pra' district. Position C and Position D were inside the passenger ports, nearby the downtown. The shipyard area and the marina have been analysed by measurements in Positions E. Overall, five measurements positions were considered during the survey, trying to give as far as possible an accurate characterization of port noise.

Two Class 1 EN/IEC 61672 sound level meters were used for the campaign, together with the corresponding calibrators. All the devices were re-calibrated according to IEC 61672 standard before the beginning of the survey. Measurements have been performed for different durations. Long term measurements lasted seven consecutive days, while short term measurements covered a duration of three days in Position B or 1.5 hours during the day period of a working day in Position C. The long term measurements continuously logged Leq data in dB(A) with a value every 15 minutes. During the short term measurements dB(A) Leq value was recorded once a minute in Position B and every 5 minutes in Position C, so that an accurate description of noise time history was depicted. The survey was implemented during Summer 2017 and February 2018, with temperatures above 0°C and wind speed that always respected the limit value of 3 m/s.

The procedure above described mainly adopts methodology and equipment required by the Italian regulations for environmental noise measurements [5], that is anyway similar to those followed in the most EU countries.

Figs. 2, 3 and 4 respectively show Leq values in Position A, Position D and Position E over a week. The range of variation has been at least 30 dB(A) wide during the diverse tests, with nights characterized by lower noise levels, but with some peaks also during that period, probably in correspondence with upload or download operations. The difference between working days and holydays in the containers terminal does not appear so marked as one could expected (Fig. 2), while in the tourist port the noise levels the days Saturday 1st July and Sunday 2nd July were noticeably lower than the other days, when the shipyards and workshops located there are working (Fig. 4). This is an element that makes the commercial port like an industrial area and suggests the need of a certain number of long term measurements covering the different sectors of the port for the purpose to identify the main noise patterns, since these seem to be not obvious and differ from one part to the other. It must be noticed that the influence of seasonality has not been analysed but it is probably not negligible, mainly for the passenger zone of the harbour.

Noise spectra in one octave bands are then reported in Fig. 5 for Position A, in Fig. 6 for position D and in Fig. 7 for Position E. The spectra show for Position D and Position E the overlapping of urban noise, and particularly of traffic noise, on the port emissions. Without the possibility to separate the different sound energy contributions reaching the sound level meter, the chance to obtain meaningful information is strongly compromise. This also casts a shadow on the time history previ-

ously commented. Within them we find superimposed sources operating inside and outside the harbour, generating a noise jam in which is difficult to identify the diverse contributions.

As mentioned above, in order to better understand the noise pattern in the different sectors of the port, two attempts were made to perform short term measurements.

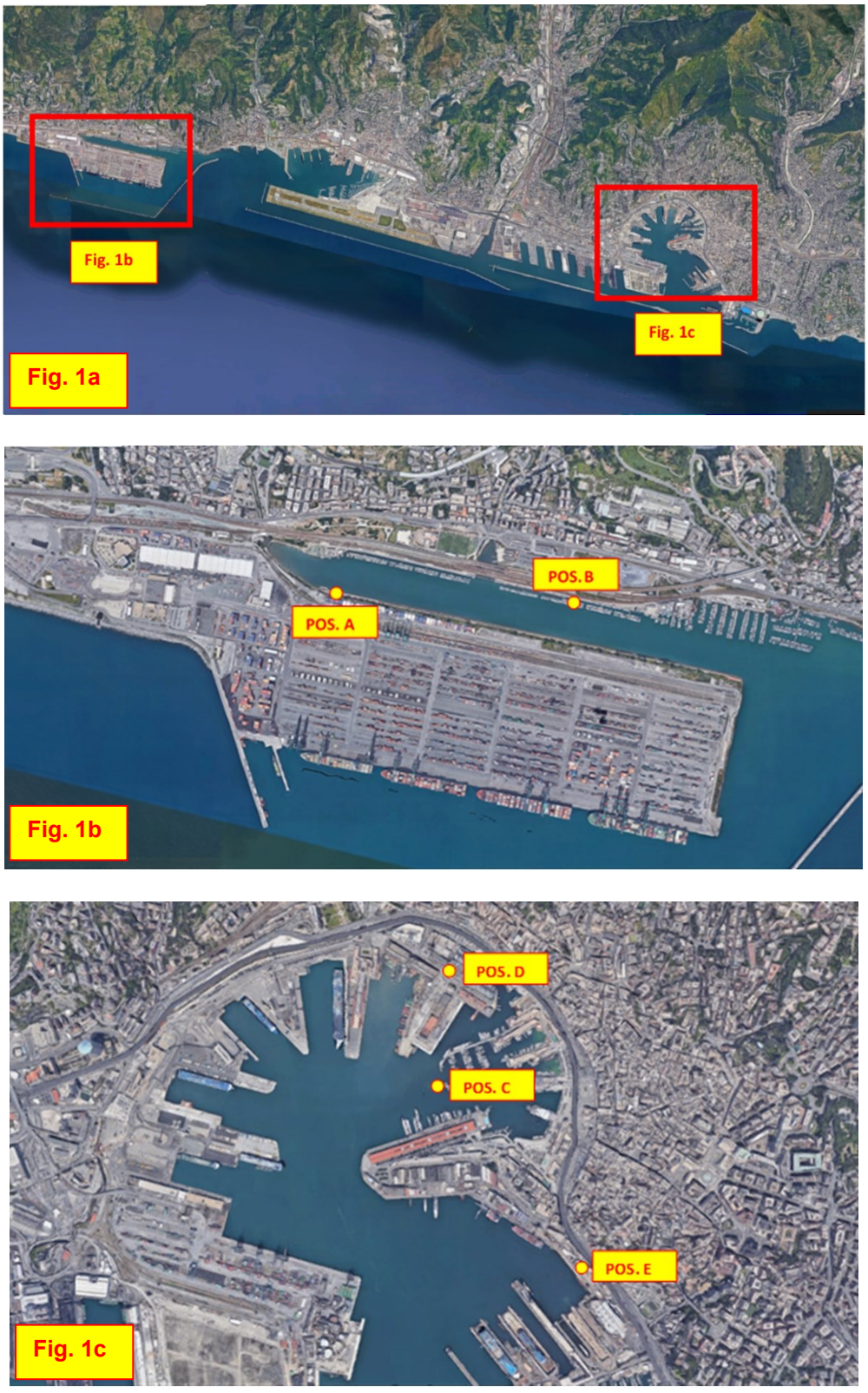

Fig. 1. Measurement positions inside the Port of Genoa: (a) general distribution; (b) measurement positions in the area of Voltri Container Terminal; (c) measurement positions in the area of Passenger Port and Marina

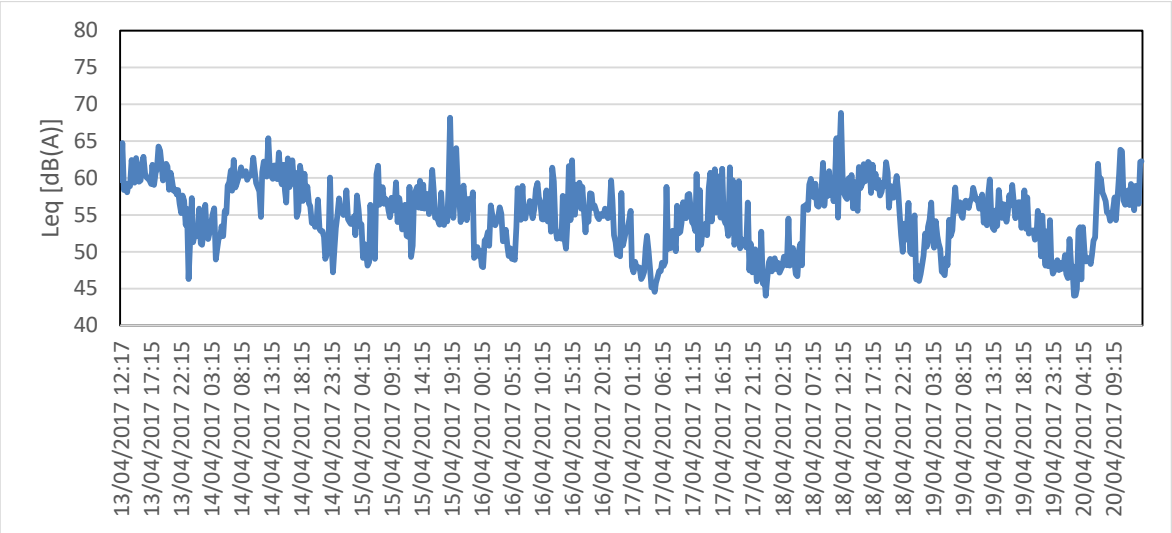

Fig. 2. Noise time history in the area of Voltri Container Terminal – Pos. A – One week duration.

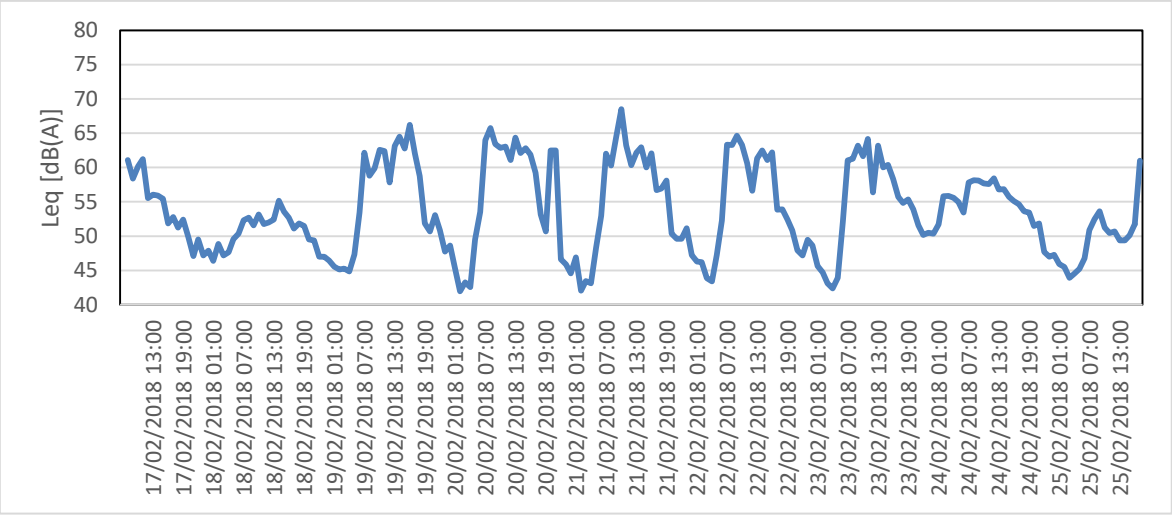

Fig. 3. Noise time history in the area of Passenger Port – Pos. D – One week duration.

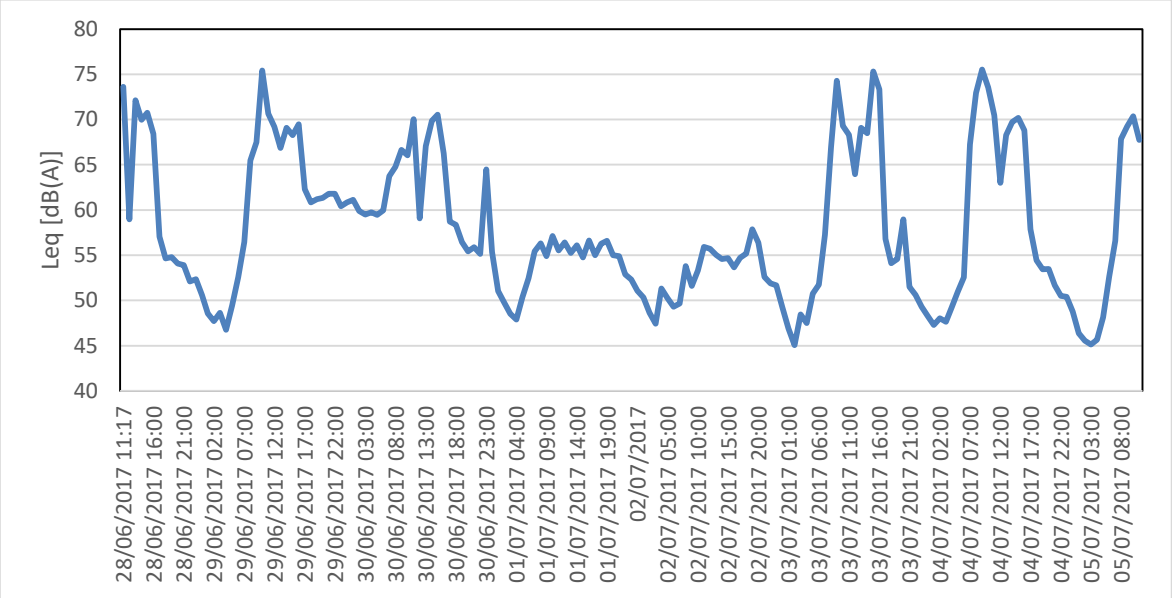

Fig. 4. Noise time history in the Marina area– Pos. E – One week duration.

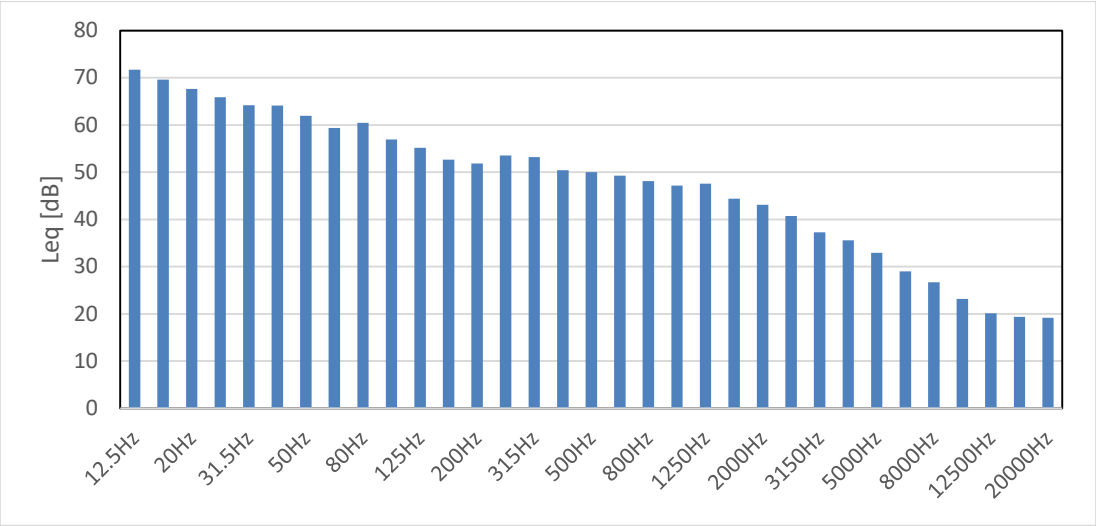

Fig. 5. Noise spectrum in the area of Voltri Container Terminal – Pos. A – One week average

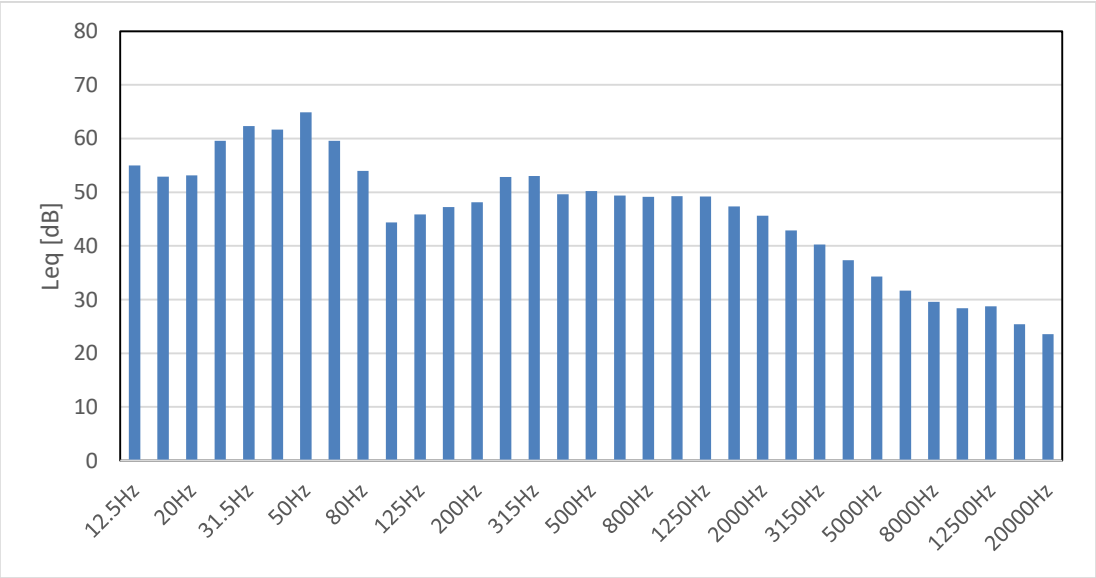

Fig. 6. Noise spectrum in the area of Passenger Port – Pos. D – One week average

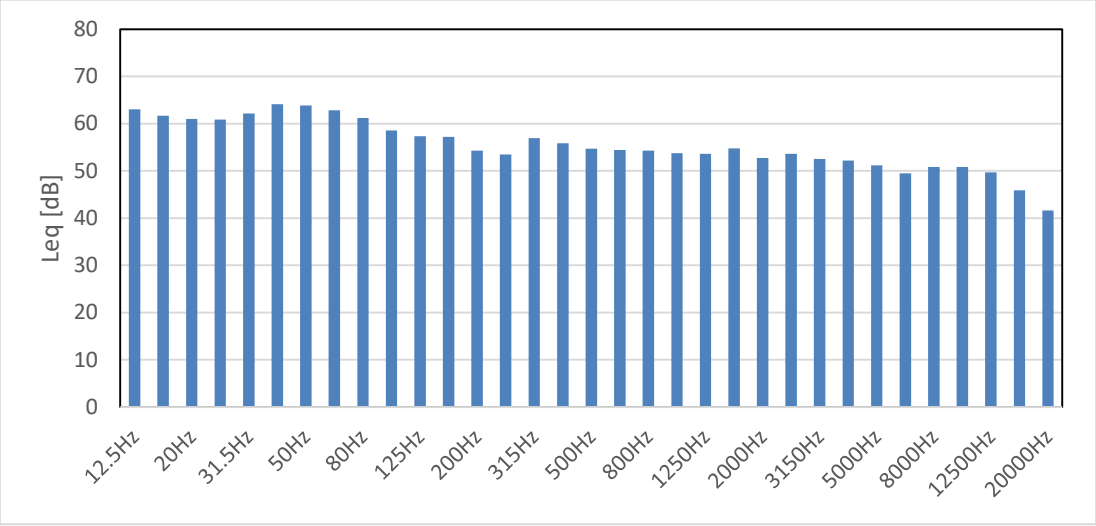

Fig. 7. Noise spectrum in the Marina area – Pos. E – One week avarage.

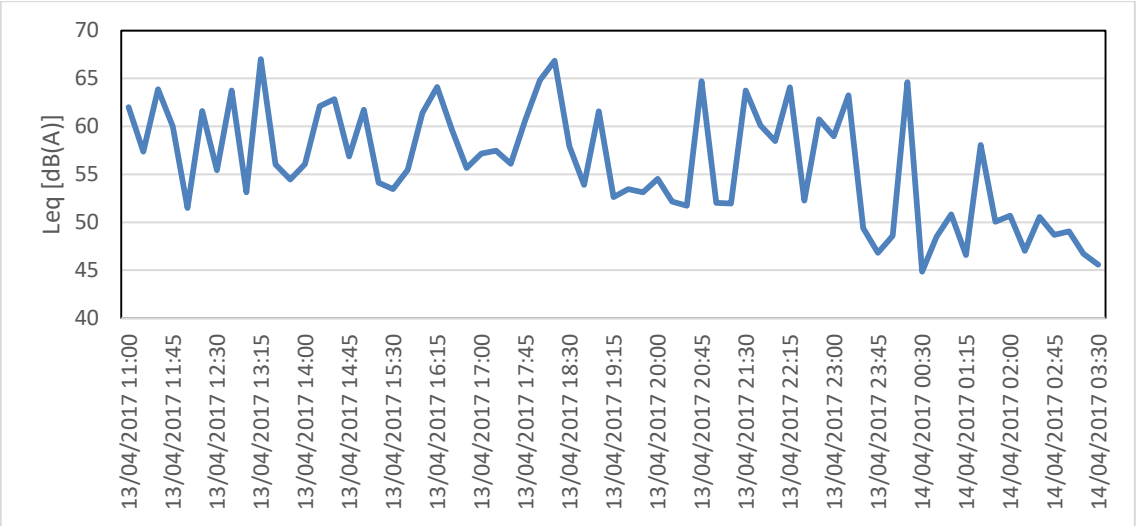

Fig. 8. Short term noise time history in the area of Voltri container terminal – Pos. B.

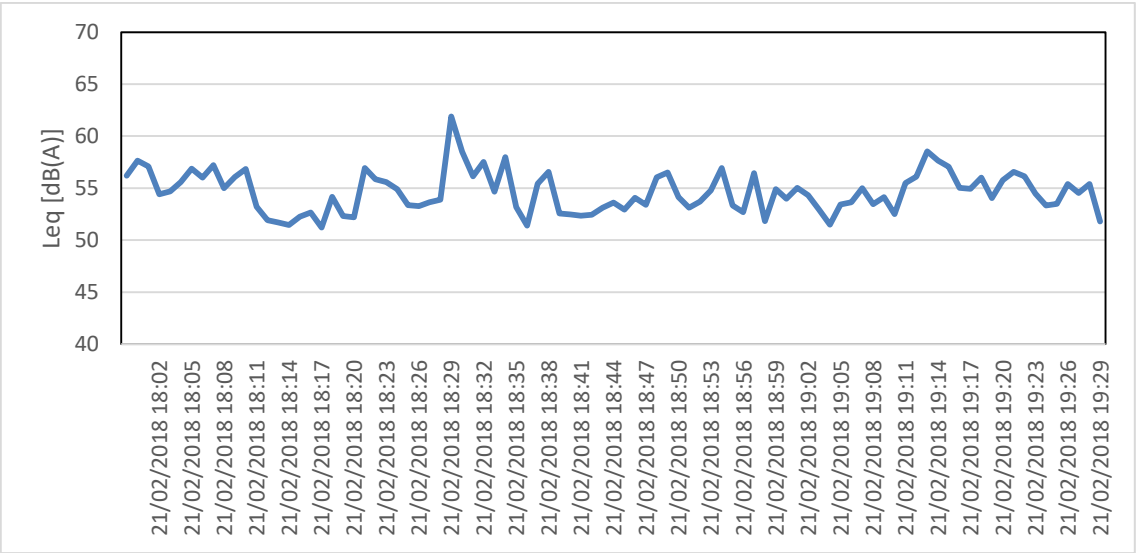

Fig. 9. Short term noise time history in the area of Passenger Port – Pos. C.

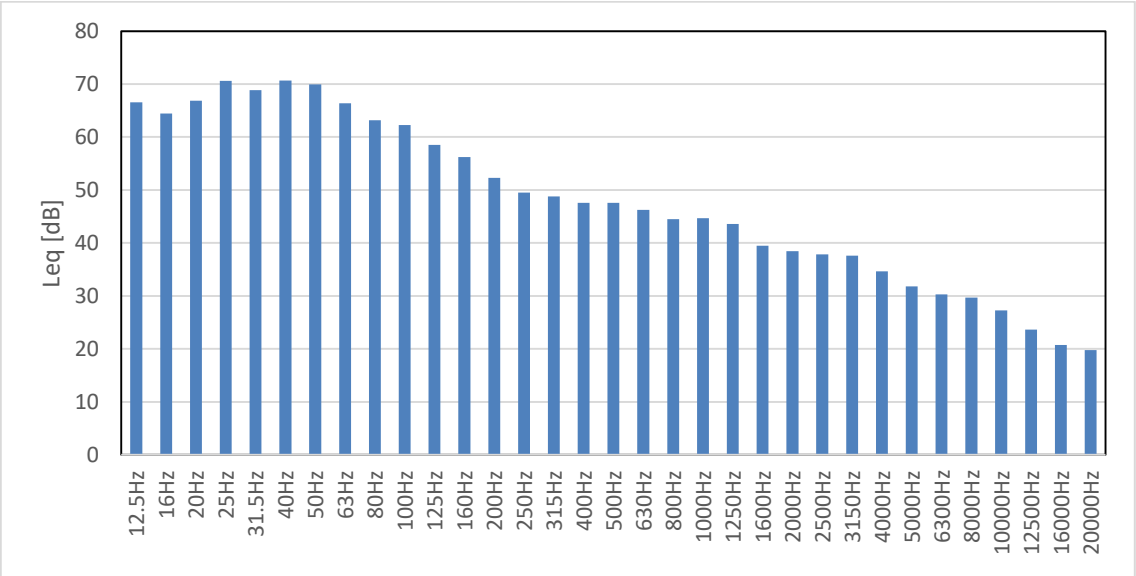

Fig. 10. Short term noise spectrum in the area Passenger Port – Pos. C – ninety minutes duration

A first short term measurement was set near the Voltri Container terminal (Position B), just in front the upload/download area. Fig. 8 shows the time history over seventeen hours with a Leq value every 15 minutes.

A similar attempt was made for the Marina, for which a 90-minute measure with one-minute time step obtained the data reported in Fig. 9 (Position C). During the measurements two ship passages were observed, but these events have a weak correspondence in the time history. And in general the amount of information that is possible to extract from recorded data is quite limited.

Both Fig. 8 and Fig. 9 suggest that short term measurements are little useful in characteriz-ing port noise, if a specific target, e.g. a specific source, is not identified. Correspondent spectrum is shown in Fig. 10 for Pos. C, but the same remark can be repeated. The quantity of information coming from the spectrum is really limited, since the possible masking effect of the other sources is not quantified, as well as the recognisability of the "target noise", i.e. the passing ship, is little. Probably the spectrum analysis should be restricted to when the ship passes, but even in this case any generalization appears problematic.

3. Discussion of results

The measurements carried out generally show a wide range of values of L_{DEN} and Lnight indicators, with noise levels that anyway appear to generally comply with the legal limit values for both the night and the day-evening-night period. However, this result clashes with the various exhibits addressed to the Municipality by the citizens, as well as with the hostile position of the exposed citizens with respect to port noise.

According to the authors, this inadequate assessment of the impact of port noise on the exposed population derives from two orders of reasons completely different, but which here converge. On one hand, the current national and international laws do not effectively rule the noise emitted by ports and ships. The European Union has not specifically regulated the noise emitted by ships or irradiated by ports. Internationally, the regulatory framework is fragmented and incoherent, as discussed in Borelli et al. [6], without the recent years having seen a real change in the situation. At national Italian level, a decree aimed at regulating port noise, required by a 1995 law, has never been issued. On the other hand, the present survey highlighted the limits of current methodologies for measuring the noise radiated by ports. Mainly following the dictates of the Italian national standard [5] that standardizes environmental noise measurement procedures, only partial data have been obtained, which do not appear capable of effectively describing port noise and its actual impact on the population.

A port shows noise features different from a road or a railway o an airport. It is more similar to an industrial site but even more complex to be analysed, due to the presence of ships (moored or on the way), of seasonality, of railways and road vehicles, of random sources, etc., which make the measure and the characterization very tangled. Moreover, urban noise tends to superimpose on the port noise, so that the specific contribution coming from ships and port infrastructures is often no more detectable. A clear example comes from Fig. 6, where the road noise coming from an adjacent flyover highway masks the harbour noise at low frequencies. Furthermore, time histories collect events that do not belong to the port area, but that the sound level meter records. In Fig. 7 the large pressure levels for high frequencies suggests the presence of an unidentified external source influencing the measure.

It is hence impossible to identify the single contributions of the sources and then adopt effective countermeasures for the purpose to control it. A new approach is then required, which respects the complexities, considers and characterizes the different noise sources, and achieves an accurate modelling of the port acoustic field. With regard to the measures, the following is observed:

- At the same time close and remote measures are to be made, so assessing the propagation paths and the correlation between the near field (close to the diverse sources) and the far field (collecting the contributions coming from the overlapping sources).

- Specific measures designed to characterize the sources are needed. For this purpose, intensimetric measurements and acoustic cameras should be considered as an alternative to traditional sound pressure meters in order to log more meaningful and helpful data on noise field and sources.
- There is the need for adequate investments that permit protracted and detailed measurement campaigns. Similarly to the methodology adopted for urban noise mapping, the harbour must be explored with a combination of long term measurements, aiming to find the general noise patterns, and short term measurements, addressed to cover the entire port area with a sufficient spatial detail.

Concerning the port noise modelling, two different approaches are possible. Either every single source and the geometry of the port area are characterized, and then modelled by ray tracing according to the usual method. Or measures are taken on the harbour perimeter, assigning then attempt values to the sound power level of the sources with a "try and correct" technique, until the correct values are determined [7] and the acoustic field is accurately described.

4. Conclusions

In the field of port noise there are still no standardized and shared procedures aimed to sound characterization and noise analysis. Unlike what happens for roads, airports or railways, a relatively small amount of research is available, while the nature of the phenomenon makes it complex and difficult to analyse. The acoustic measurements made in the Genoa port have substantially confirmed these elements. Without an advanced procedure for noise characterization, measurements of sound pressure levels do not allow to define exactly the sources of noise, nor modelling of the sound field for the purposes of Strategic Acoustic Mapping or any other analysis of the sound field you want to produce. It therefore appears necessary to develop new specific methods for port noise characterization. So new measurement modes with acoustic camera or with other instruments able to evaluate the direction of origin of the sounds, or, even better, their sound intensity.

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REFERENCES

1 Badino, A., Borelli, D., Gaggero, T., Rizzuto, E., Schenone, C., Analysis of airborne noise emitted from ships, (2012) Proceedings of the 14th International Congress of the International Maritime Association of the Mediterranean, IMAM 2011, 2, pp. 1001-1010.

2 Di Bella, A., Evaluation methods of external airborne noise emissions of moored cruise ships: An overview, (2014) 21st International Congress on Sound and Vibration 2014, ICSV 2014, 2, pp. 964-971.

3 Schenone, C., Pittaluga, I., Repetto, S., Borelli, D., Noise pollution management in ports: A brief review and the eu MESP project experience, (2014) 21st International Congress on Sound and Vibration 2014, ICSV 2014, 2, pp. 1364-1371.

4 Di Bella, A., Remigi, F., Fausti, P., Tombolato, A., Measurement methods for the assessment of noise impact of large vessels, (2016) ICSV 2016 - 23rd International Congress on Sound and Vibration: From Ancient to Modern Acoustics.

5 Italian Decree D.P.R. 16.3.1998 Sound pollution detection and measurement techniques.

6 Badino, A., Borelli, D., Gaggero, T., Rizzuto, E., Schenone, C., Acoustic impact of ships: Noise-related needs, quantification and justification, (2012) Proceedings of the 14th International Congress of the International Maritime Association of the Mediterranean, IMAM 2011, 2, pp. 961-969.

7 Farina, A.; Galaverna, P.; Truffelli, G.; Simplified mapping algorithm for fast surveys, requiring minimal input data, 13th International Congress on Sound and Vibration 2006, ICSV 2006, v 4, p 2583-2590.