STANDARDS FOR PROJECT JOMOPANS: OCEAN NOISE MONITORING FOR THE NORTH SEA

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Abstract:
At this moment, there are no international standards for monitoring ambient noise in the ocean. Such standards would require consensus on a number of topics: (i) terminology for describing the monitoring of underwater ambient noise; (ii) specification, performance requirements, calibration and deployment of the measurement equipment; (iii) analysis of the measured data obtained from monitoring. JOMOPANS is a project funded by the EU INTERREG programme with the aim of monitoring the ambient noise in the North Sea in response to the requirements of the Marine Strategy Framework Directive.
Within the project, the above activities are being standardized so that all partners use a common approach in order that data obtained within the project are comparable. This paper describes some of the standardization activities in the project, including the provision of protocols for describing the key practical activities within the project, and a benchmarking exercise to ensure that data analysis undertaken by the partners is mutually equivalent.

Keywords: *standards, ocean noise, monitoring*

1. INTRODUCTION

Project JOMOPANS is funded by the EU INTERREG programme. The aim of the project is to develop a framework for a fully operational joint monitoring programme for ambient noise in the North Sea. The outputs will be the tools necessary for managers, planners and other stakeholders to incorporate the effects of ambient noise in their assessment of the environmental status of the North Sea, and to evaluate measures to improve the environment.

Sounds are omnipresent in the underwater environment and can be produced by natural sources (waves, weather, and animals) and anthropogenic sources (shipping, construction, and geophysical surveying). International concern increasingly focusses on the potential negative effects of anthropogenic underwater noise on sensitive marine fauna. Sound sources, sound transmission, and the distributions of vulnerable species in the North Sea are all transnational questions which must be tackled transnationally, as specifically required by the Marine Strategy Framework Directive [1].

This project will deliver a combination of modelling and high quality measurements at sea for an operational joint monitoring programme for ambient noise in the North Sea. The use of consistent measurement standards and interpretation tools will enable marine managers, planners and other stakeholders internationally to identify, for the first time, where noise may adversely affect the North Sea. The project will explore the effectiveness of various options for reducing these environmental impacts through coordinated management measures across the North Sea basin. Figure 1 shows the location of the 14 JOMOPANS monitoring stations and the partners on the project.

Fig. 1: JOMOPANS monitoring stations (red dots) and project partners.

JOMOPANS has a duration of three years from January 2018 to December 2020. The project consortium has 11 partners from 7 countries. The project coordinator is Rijkswaterstaat in The Netherlands. Figure 2 shows the structure of the project and the relationship between the different work packages and activities.

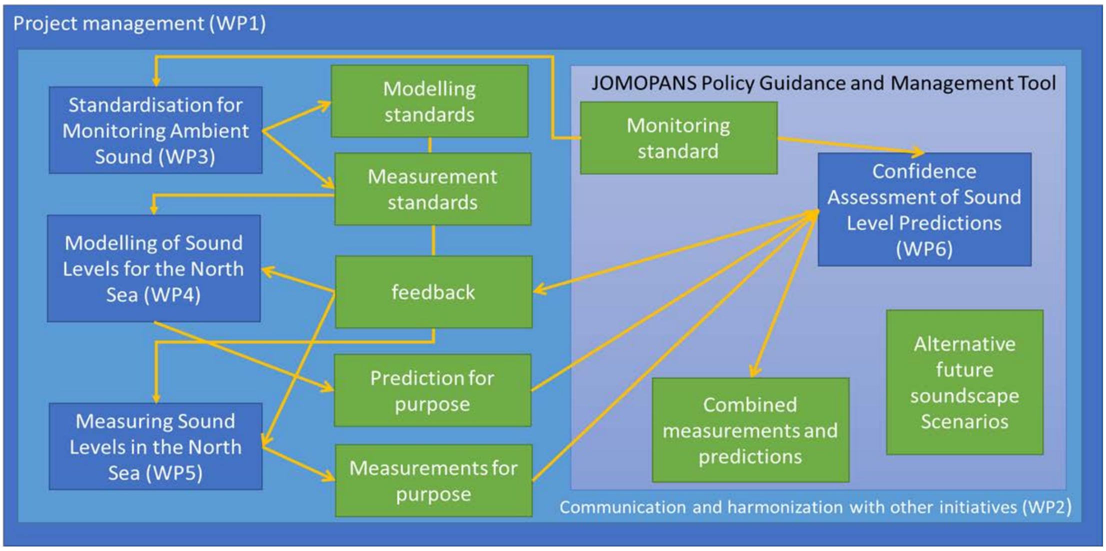

Fig. 2: Project structure for JOMOPANS

At this moment, there are no international standards for monitoring ambient noise in the ocean. In JOMOPANS, there is a need to standardize some activities so that all partners use a common approach and so that data obtained within the project are comparable. Therefore, we are developing standards within the project which address this need, and which will ultimately feed into the development of international standards. The work on standardization includes a number of topics:

- terminology for describing the monitoring of underwater ambient noise;
- performance requirements, calibration and deployment of the measurement equipment;
- analysis of the measured data obtained from monitoring.

The standardisation work in JOMOPANS also includes benchmarking of acoustic propagation modelling of underwater sound fields, but this work is not described in this paper.

2. TERMINOLOGY

There are a number of different metrics that may be used as measures of the sound pressure [2-6]. In the JOMOPANS project, the sound field metric chosen for estimation of the sound field is the sound pressure level (SPL). The SPL is calculated from the mean-square sound pressure described in ISO 18405 [2].

The temporal observation window and the temporal analysis window are both defined as being equal to 1 second [7]. The windows are not aggregated into longer analysis periods and the statistics of the ambient noise are calculated from the 1 second windows alone.

In JOMOPANS, the measured SPL values are filtered into 34 one-third octave bands (base 10) with centre frequencies in the range 10 Hz to 20 kHz [4]. In the JOMOPANS project, the base 10 calculation of one-third octave frequencies and bands (equivalent to one tenth decades) is the chosen definition and nomenclature. This is in accord with IEC 61260:1-2014 [4] and with the most common usage adopted throughout the field of acoustics.

An examination is made of the distribution of estimated SPL values averaged over 1 second and evaluated in the one-third octave bands described above. The statistical percentiles are calculated based on the above distribution of values [8].

Note that in the JOMOPANS project, the physical quantity being estimated is considered to be the ambient noise in the ocean; that is, all sound except sound associated with a specified signal and except acoustic self-noise. Note that all sound is to be measured and considered to be of interest (all sounds in the ocean are considered to be “signal”). Note that in some other ocean monitoring projects, the quantity being estimated is given the name “ambient sound”.

3. EQUIPMENT PERFORMANCE, CALIBRATION AND DEPLOYMENT

This aspect of the standardisation falls into three categories

- Specification of required equipment performance
- Specification of calibration requirements for instrumentation
- Specification of deployment methodology

Regarding specification of required equipment performance, key equipment parameters to be specified include frequency range, dynamic range, sensitivity, directionality, sampling rate, filtering, system self-noise. Table 1 shows the agreed minimum equipment performance [9].

Regarding the calibration requirements for instrumentation, these include calibration methodology, traceability to international standards, specification of measurements required, frequency range, and uncertainty requirements [9]. Calibrations are completed on all devices before and after the deployments, with absolute calibrations obtained for any measurement hydrophone and recording system deployed for the study. Calibrations are ideally completed in the same (or as close as possible) mounting configuration and temperature/depth for which the hydrophone is likely to experience in the field. Field calibrations are conducted prior to deployment and post recovery to ensure there has been no major change in the hydrophones response over the course of the measurement. Recommended frequency range for calibrations should at minimum cover the frequencies of interest between 10 Hz and 20 kHz at least third octave centre frequencies. All calibrations must be traceable to internationally-recognised standards

Regarding the specification of deployment methodology, guidance is provided on recommended methodology for deployment, including rigging and anchoring [9]. Recommendations are also made for methods to mitigate the influence of parasitic signals caused by contaminating artefacts. In addition to the self-noise of the measuring system itself, the measured data may also be contaminated by signals originating from the platform or method of deployment. This is often called “platform noise” or “deployment noise”. These parasitic signals are due to the deployment method for the hydrophone and recording system and its interaction with the surrounding environment (e.g. current, wave action, etc) and include such effects as cable strum, and flow noise, mechanical noise, etc.

Procedures are also recommended for quality assurance when retrieving and storing data. Recommendations are also made for measurement and recording of auxiliary data, for example, wind speed, water depth, air temperature, GPS location, seabed type, etc.

In JOMOPANS, some monitoring stations consist of autonomous recorders which are archival systems that are deployed for a fixed time duration (typically three or six months). However, a number of JOMOPANS monitoring stations are hardwired to the shore and provide continuous monitoring with 100% duty cycle.

Metric	Specification
Frequency range:	Nominally: 10 Hz – 20 kHz Note that to fully record the 34 third-octave bands in this frequency range requires measurement over the range 8.91 Hz to 22.39 kHz. Note: MSFD focus frequencies of interest are the 63 Hz and 125 Hz third-octave bands.
Dynamic range:	Minimum 16 bit (nominal dynamic range 96 dB), Preferably 24 bit (nominal dynamic range 144 dB) Note: actual dynamic range is from noise floor defined by system self-noise to the maximum measureable undistorted sound pressure
Sensitivity:	Ideally in the range: -165 to -185 dB re. 1 V/μPa
Frequency response	Ideally invariant with frequency (flat response) in the range 10 Hz to 20 kHz Note: see description of recorder performance when hydrophone is rigidly attached to body.
Directionality:	Omnidirectional to within +/- 1 dB up to 20 kHz azimuthal, and to within +/- 2 dB in vertical elevation Note: see description of recorder performance when hydrophone is rigidly attached to body
Sampling rate:	Minimum of 44 kHz Ideally at least 48 kHz (to capture upper band limit of 22.39 kHz for the 20 kHz third-octave band)
Filtering:	Any filter characteristics should be known and corrections applied (low pass and high pass filtering caused by instrumentation) Note: any low frequency roll-off in recorder performance due to high pass electronic filtering must be measured so that suitable corrections can be applied.
System self-noise:	Ideally, better than 64 dB re 1 μPa^2/Hz at 63 Hz; Ideally, better than 59 dB re 1 μPa^2/Hz at 125 Hz. Ideally, 6 dB below the lowest sound level. Note: the self-noise of some of legacy instrumentation used in the project (such as autonomous recorders) may not meet this specification.

Table 1: JOMOPANS agreed minimum equipment performance.

4. DATA ANALYSIS

Specifications have been defined for methods of calculating the key metrics from measurement data. Guidance provided on initial data processing includes removal of contaminated data, checks for clipping and distortion, checking for spurious signals. Guidance is also provided for software control and maintenance [10].

As a check on performance of software algorithms used by partners, benchmarked data sets were created for validation of analysis algorithms. The benchmarking exercise was carried out for project partners to compute one third octave band SPL levels from a common synthetic data set. The intention was to check how robust the guidance was and to compare the levels reported by partners following their own implementation of the processing.

Project partners were given two data files and instruction to compute the required metrics. The two files were generated with the same random seed and the two noise spectra were coloured white and pink (this description of the noise-types in the files was not given to participants at the time of circulating the simulated data). Partners returned the spectral levels for each second of the two 100 second files individually and the results were compared, with sufficient agreement obtained between the partners' results.

5. SUMMARY AND CONCLUSION

Within JOMOPANS, standard procedures have been produced on (i) acoustic terminology; (ii) equipment performance, calibration and deployment, and (iii) processing of measurement data. In addition, a benchmarking exercise has been undertaken to enable partners to compare their data analysis software by processing the same sets of synthesized data of known characteristics.

The JOMOPANS standards will also be made available to the wider acoustical community. They will be submitted for discussion in standardisation committees to provide input to the drafting of international standards and the preparation of new work item proposals, for example within ISO.

JOMOPANS is also communicating with other relevant projects in Europe and across the world, like JONAS, QuietMed, UNAC-LOW, COMPASS, ECHO, Adeon and MarPAMM. This enables JOMOPANS to share valuable information on the approaches used and the lessons learned, and just as JOMOPANS builds on the original work of the BIAS project, these existing and future projects can build on work carried out within the JOMOPANS project.

Finally, during the JOMOPANS project underwater noise measurement data will be collected throughout 2019 at the 14 measurement stations. These measurements form a valuable data set which can be shared with experts around the world.

6. ACKNOWLEDGEMENTS

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