UNDERWATER NOISE MAPPING METHODOLOGIES FOR SHALLOW WATERS

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1. Motivation of the work

- Methods for evaluation and quantification of underwater noise needed.
- European Normative(2008/56/EC) asks for specific solutions but there's no standard answer. Evaluation of the good environmental status of the European waters is needed.
- ECODRAGA experience calculating source level of a dredger. Environmental impact studies such as punta Langosteira blastings or Vigo harbor pilot driving.
- Shallow water propagation is complex and less investigated, good examples in our area/location: multipath, depth variable speed of sound, influence of the bathymetry and seabed, etc.

2. Objectives

O1 Study and evaluation of the underwater noise measurement methodologies.
O2 Study and evaluation of Propagation Losses calculation
O3 Study and calibration of underwater noise prediction software.
O4 Characterization and classification of the different noise sources available in Ría de Vigo.
O5 Development of noise map construction methodologies.
O6 Construction of an underwater noise map of Ría de Vigo.

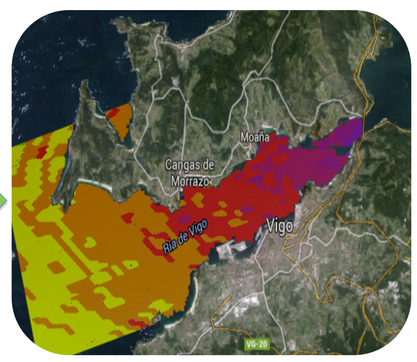

Figure 1: Underwater noise map recreation

3. Research plan

1 Study about the state of art of underwater noise measurement methodologies. Using databases as sciencedirect, scopus, WOK, etc.
[Oct. 2015-Feb. 2016]

2 Evaluation of underwater noise measurement methodologies [1][2]. Experimental measurements in shallow water. Development of specific measurement protocols.
[Mar. 2016-Jun. 2016]

3 Development of methods and protocols for calculating propagation losses based on experimental measurements. Field measurements with calibrated source .
[Jul. 2016-Oct. 2016]

4 Underwater noise sources recording. Measurement of various sources of underwater noise in Ría de Vigo.
[Jul. 2016-Ago. 2016]

5 Classification of the recorded sources. Creation of a detailed database in web format using data from sources measurements task. Study and evaluation of automatic classifiers. Development of an automatic classifier testing the usefulness of the database proposal.
[Nov. 2016-Feb. 2017]

6 Study of software propagation models. Comparison of experimental and software propagation losses methodologies. Calibration of software models according to experimental measurements.
[May.2017-Jun.2017]

7 Study of underwater noise mapping methodologies development. Evaluation of the usefulness of the models obtained in the previous tasks for the development of underwater noise maps, study of the uncertainty of the noise map data according to the uncertainty of the input data to the model.

Focusing on 2 solutions

dBSea	**Bellhop3D**
-Continuous/static sources, predictable traffic.	-Real time/dynamic sources, unpredictable traffic
-3 different solvers	-Ray tracing solver

[Jul.2017-Agos.2017]

8 Development of underwater noise map of the Vigo estuary. Validation campaigns measurements:
-2 campaigns: summer and winter
-3 to 5 days of sampled measurements
-3 different and simultaneous locations away from main transit
[Sep.2017-Feb.2018]

Next year planning… (7 to 8) Focusing on possibilities of dBSea and Bellhop3D as software solutions for noise map modeling. Creation of Ría de Vigo underwater noise map and validation trough measurements campaigns.

4. Results and discussion

Task 3 data have been obtained during Adricristuy dredger measurements session [3] in Moaña harbour, Pontevedra:

- A methodology to calculate Propagation Losses, based on experimental measurements of the measured source and a calibrated source emitting tones in 1/3 octave bands, was established.
- A measurement set up and data processing were designed and successfully employed to provide received levels at different depths and distances from the measured and calibrated source.

Task 6 was completed in conjunction with task 3 using different models of private software dBSea [4]:

- A methodology to calculate Propagation Losses with dBSea, based on calibrated source locations and field measurement data, was established.
- 3 different solver algorithms were tested and a best fitting model, as a function of distance and frequency, was obtained.

Task 3 and 6 results have been presented at UACE 2015 [3]. The most important research results are synthetized in figure 2:

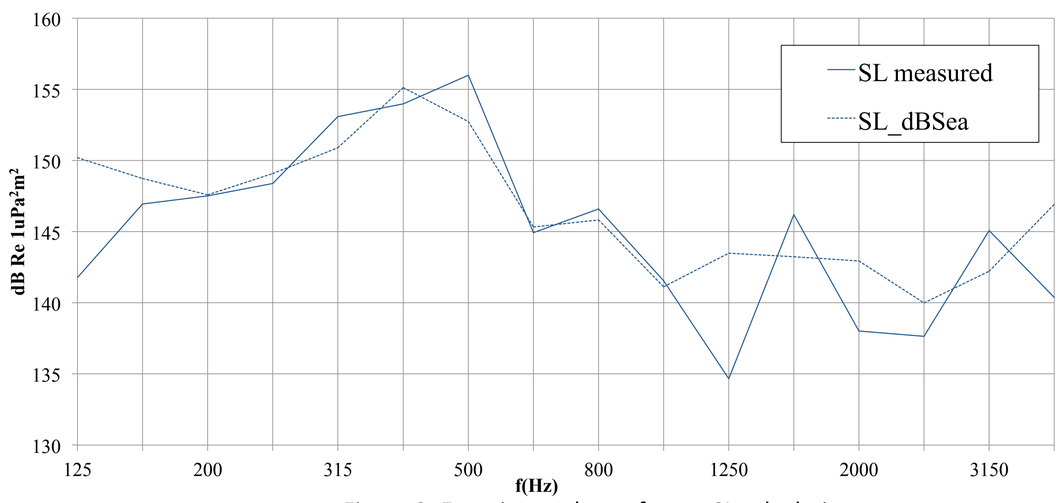

Figure 2: Experimental vs software SL calculation

- ✓ SL fitting between both experimental and software methods is good from 160-1000 Hz, above 1kHz gets worse but still acceptable.
- ✓ In view of the results, the use of this software to compute propagation losses is reasonable under conditions of reliable information about bathymetry, sound speed profile and water and seafloor properties.
- ✓ Further work is required in order to get a quantification of the validity of the results depending on the quantity and quality of dBSea configuration parameters.

Task 4 has been completed with several measurement sessions in Ría de Vigo as explained in [5]:

- More than 100 recordings of 12 different type of vessels were obtained and accompanied by descriptive details such as type of vessel, location of the recording equipment, weather conditions, etc. An specific methodology for this recording creation was also established.
- The sounds were recorded in real conditions, so contain both natural and anthropogenic environmental noise. The aim was to provide a database of real sounds that researchers could use, for example, to train vessel detectors and classifiers.

Task 5 has been completed using all the data obtained in task 4:

- A selection of 90 recording was used to develop an online database with sound recordings accompanied by fully descriptive details as can be seen in figure 3.
- To demonstrate the usefulness of the database, a vessel classifier was developed, based on cepstral coefficients and GMMs.

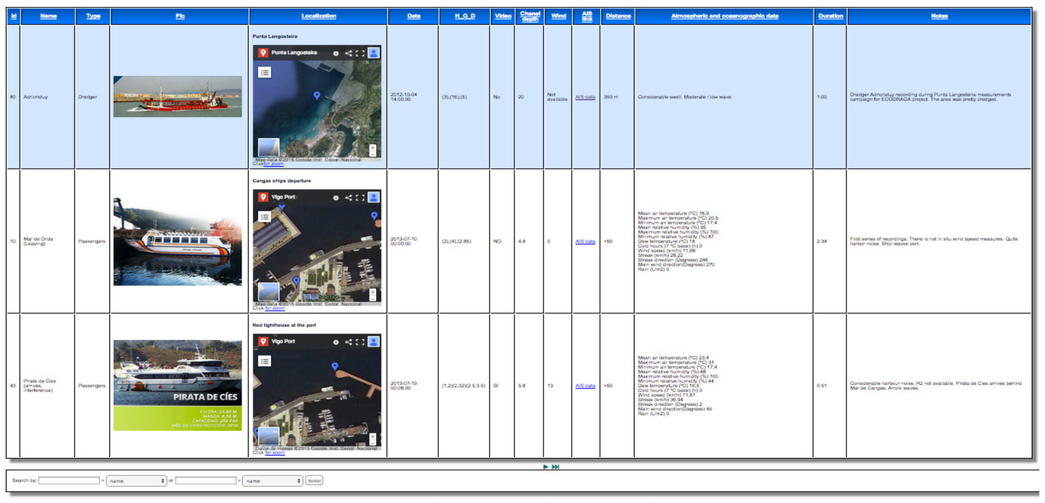

Figure 3: ShipsEar online snapshot

Main results of tasks 4 and 5 have been published in Applied Acoustics [5]:

- ✓ ShipsEar, a database of underwater sounds produced by vessels, with sound recordings accompanied by descriptive details such as type of vessel, location of the recording, weather conditions, etc. This database can be consulted at http://atlanttic.uvigo.es/underwaternoise/.
- ✓ The 12 original vessel classes were merged into 4 classes and, using this distribution, the system obtained a 75.4% classification rate with 100% accuracy in detecting background noise and 80% and 76.5% classification rates for the best classes.
- ✓ Further work: test more sophisticated state-of-the-art algorithm for the classifier (SVMs or neural networks); monitor vessels positions and improve hydrophone response at low frequencies.

5. References

[1] ANSI/ASA S12.64-2009/Part 1, "Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements", American National Standards Institute, New York, (2009).
[2] S P Robinson, P D Theobald, G Hayman, L S Wang, P A Lepper, V Humphrey, S Mumford, "Measurement of noise arising from marine aggregate dredging operations, Final Report. MALSF (MEPF Ref no. 09/P108)", Published by the MALSF, ISBN 978 0907545 57 6 (2011).
[3] David Santos-Domínguez, Soledad Torres-Guijarro, Antonio Pena-Gimenez, "Analysis of dredger noise based on experimental and simulated source level calculations", UACE2015 3rd Underwater Acoustics Conference and Exhibition 21st to 26th June 2015 Platanias, Crete, Greece.
[4] "dBSea", underwater acoustics prediction software, www.dbsea.co.uk/
[5] David Santos-Domínguez, Soledad Torres-Guijarro, Antonio Cardenal-López, Antonio Pena-Gimenez "ShipsEar: An underwater vessel noise database", Applied Acoustics Volume 113, 1 December 2016, Pages 64–69.