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.

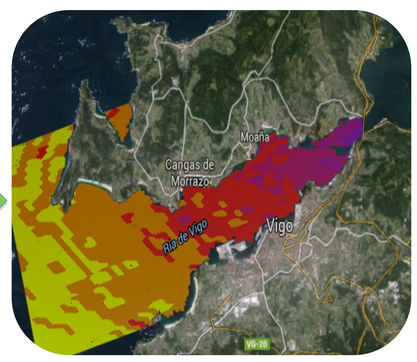

Figure 1: Underwater noise map recreation

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
-Continuous/static sources, predictable traffic.
-3 different solvers

Bellhop3D
-Real time/dynamic sources, unpredictable traffic
-Beam tracing solver

[Jul.2018-Agos.2019]

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.2018-Feb.2019]

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. *[1 year prorogation requested/accepted]*

4. Results and discussion

Task 7 and 8 were planned to finish during 2018 ***but a extension has been requested*** caused by an unexpected failure in the provision of AIS data by Puertos del Estado that directly affects the validation and adjustment of the models , therefore the noise map construction.

Some objectives of task 7 have been achieved:

- A methodology to calculate the noise produced by predictable traffic using dBSea. AIS data adjustment needed.
- A methodology to study and analyze Bellhop possibilities as a noise predictor, and also a metric that best fit our needs. AIS data adjustment needed.

Task 7 most relevant results are shown below. Results related to Bellhop, conform a paper proposal to be submitted to Applied Acoustics [30th of June, 2018].

✓ 'Continuous equivalent ship' parameter definition that allows to evaluate predictable and recurrent traffic (as passengers) using dBSea.
✓ Approximation of ría de Vigo annual passengers traffic, using this concept and the AIS data of one day.
✓ A metric to evaluate Bellhop performance have been designed based on the traffic parameters of the area. 2D and 3D Bellhop models that best fit the measurements have been obtained, mean error below 3dB. See figure 2 for complete frequency error evolution of Bellhop optimized models.
✓ The influence of the physical variables on the best models error is below 1 dB.
✓ In view of the results, the use of this Bellhop to compute propagation losses is reasonable and reliable to fast compute numerous sources. Further measurement and AIS data adjustment are need in order to validate the usability in a noise map of the area.

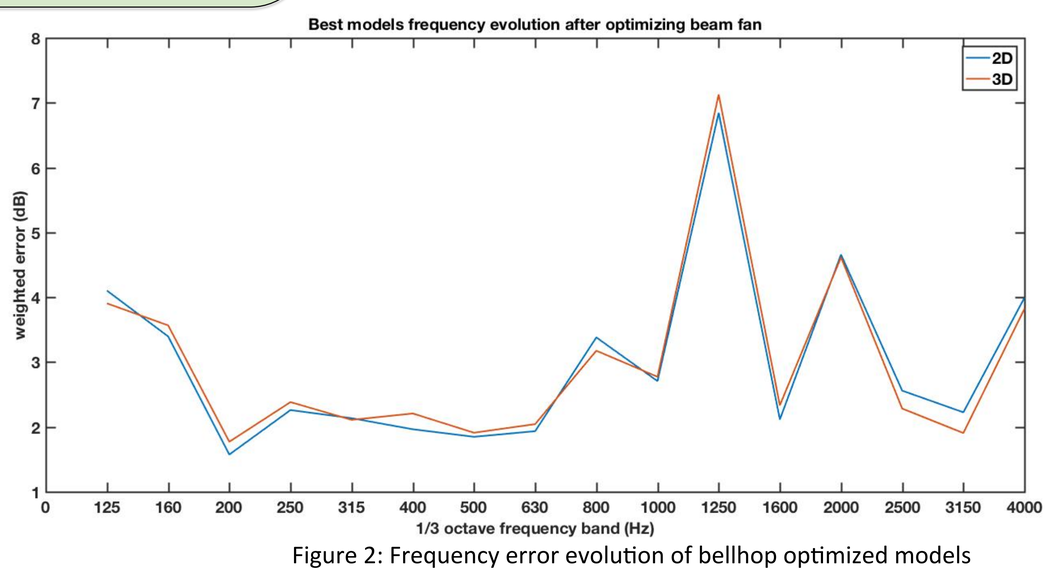

Figure 2: Frequency error evolution of bellhop optimized models

Task 8 has been interrupted due to lack of AIS data although, some objectives have been accomplished and alternative solutions proposed:

- Methodology to accomplish validation campaign during 3 days using 3 different locations along Ría de Vigo, figure 3.
- Noise map framework design, including representation, execution and decoding.
- Collaboration with Marine Traffic obtaining and installing an AIS antenna and receiver to obtain the data continuously and independently.
- Collaboration with CESGA optimizing Bellhop for the future huge amount of data simulations

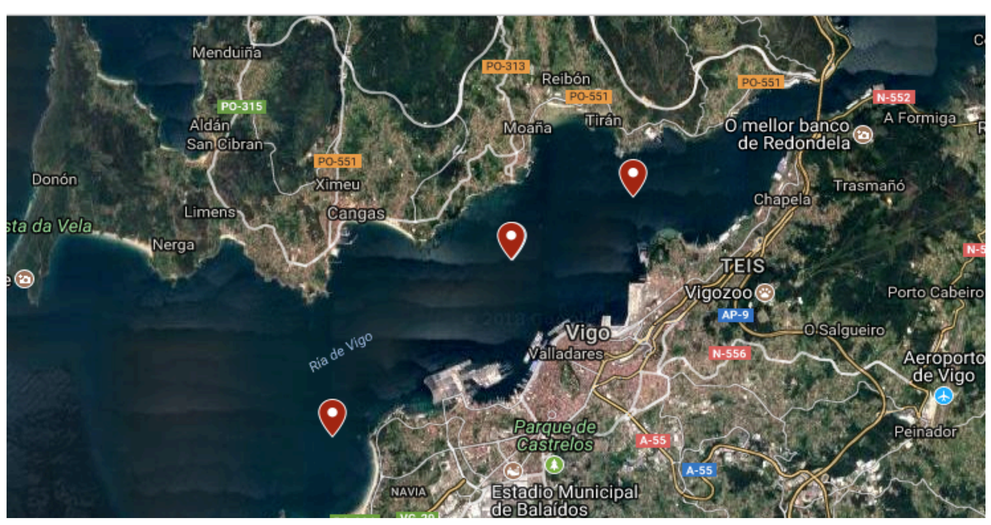

Figure 3: Summer validation campaign locations

Task 8 main results:

✓ Data acquisition, storing analysis and of a 3 days summer validation campaign.
✓ Autonomous AIS data system obtaining real time AIS data from Ría de Vigo post processing the raw data to be ready for the noise map needs.

As explained before, the lack of AIS data, the negotiation and finding of alternate solutions forced to ***prorogate the full accomplishment of tasks 7 and 8***. Because of this, a year of extension has been accepted an the research plan will accommodate to accomplish these final tasks during 2019.
The new autonomous AIS acquisition system also needs to recollect 6-9 months of data to provide an interesting amount of data in terms of traffic description.

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.