TA PROJECT REPORT

1. Project Information

Proposal reference number[1]	Ref.21_1605-JS3_CALL_1_REF_4024a_FISHES
Project Acronym (ID)[2]	FISHES (A)
Title of the project[3]	FISHES@OBSEA: Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at OBSEA
Host Research Infrastructure[4]	OBSEA
Starting date - End date[5]	9/12/21-14/2/22
Name of Principal Investigator[6] **Home Laboratory** **Address** **E-mail address** **Telephone**	Dr M. Belal National Oceanography Centre European Way, Southampton SO14 3ZH, UK mob@noc.ac.uk 0771962585

2. Project objectives[7] (250 words max.)

Key objective is to demonstrate our Distributed Acoustic Sensing (DAS) capability, i.e., ability to measure close to shot-noise broadband spatially resolved distributed measurements on the existing seafloor cable, in three different environmental conditions. This application covers access to one of three observatory access requests for this investigation. The tests conducted on the sea-floor cable will demonstrate monitoring-coverage of the multiparameter marine environmental variables space without affecting the fundamental electrical operability and connectivity purpose of the cable. The aim of this test would be to capture several marine processes, namely:

[1] Reference number assigned to the proposal by the TA-Office.

[2] User-project identifier used in the proposal.

[3] Title of the approved proposal. The length cannot exceed 255 characters

[4] Name of the installation/infrastructure accessed with this project. If more than one installations/infrastructures are used by the same project, please list them in the box.

[5] Specify starting and end date of the project (including eventual preparatory phase before the access).

[6] Fill in with the full contact of the Principal Investigator (user group leader).

[7] Write the short-term, medium and long-term objectives of the project. Use no more than 250 words.

1. Tracking: anthropogenic activity and/or structural health of the cable, albeit because of the active noise sources, e.g., scuba divers, vessel/ship traffic activity, water flow structure etc.
2. Wind/waves/currents: such events in shallower waters impact the seafloor and hence the cable more directly. Distributed strain profiling over well separated time events will help capture these signatures.

3. Main achievements and difficulties encountered (250 words max.)[8]

We have successfully managed to pick anthropogenic activities, e.g., diver motion and their underwater actions. Additionally, we have also been successful in identifying contributions from dynamic changes in physical oceanographic features, e.g., wave changes due to surface winds etc, to the ambient noise variability observed over the duration of tests.
Harsh weather enabled insights into the dynamics of the physical oceanographic features (surface wind related wave characteristics etc.), and how they contribute to significant background noise which compromises the SNR (Signal to Noise Ratio) of an event of interest. For example, when tracking anthropogenic activity across different sections of the cable, which due to its variable orientation relative to the seabed, experiences varied dynamic loading from the consequently varied physical oceanographic effects, it inadvertently suffers from deteriorating SNR. However, the ability to leverage the characteristically distinct frequency of an event and its unique temporal evolution is what helped disentangle the diver actions, despite poor SNR on occasions.
The staff/members at the facility in OBSEA were supportive and incredibly flexible. For instance, the recording of events during the test plan could not be in strict accord with the plan directives. This was largely due to the lack of controllability (orientation etc.) of the UW speaker system. Despite these logistical challenges thrown at us during the execution of the desired test plan, impromptu decisions were welcomed and incorporated by the in-field staff at OBSEA. This led to a professional execution despite immense variability in sea state and hence speaker orientation.

4. Dissemination of the results[9]

Results from the experiment will be published in high-impact journals

[8] Describe briefly the main achievements obtained and possible impacts, as well as possible difficulties encountered during the execution of the project. Use no more than 250 words.

[9] Describe any plan you have to disseminate and publish the results resulting from work carried out under the Transnational Access activity in JERICO -S3: scientific articles, books - or part of them -, patents, as well as reports and communication to scientific conferences, meetings and workshops. Highlight peer-reviewed publications. **Note that any publications resulting from work carried out under the JERICO -S3 TA activity must acknowledge the support of the European Commission – H2020 Framework Programme, JERICO -S3 under grant agreement No. 871153.**

5. Technical and Scientific preliminary Outcomes (2 pages max.)[10]

Several TBs of data has been generated which will be analysed in detail over time. However, early analysis reveals that anthropogenic cable ambient activity (as shown in figure 1), is successfully picked and identified together with other natural sources of noise, e.g., surface generated turbulence due to wind forcing etc., visible in the same figure, albeit over 200 – 300 m section, all throughout the time series. Figure 1 shows the last 700 m of interrogated cable section.

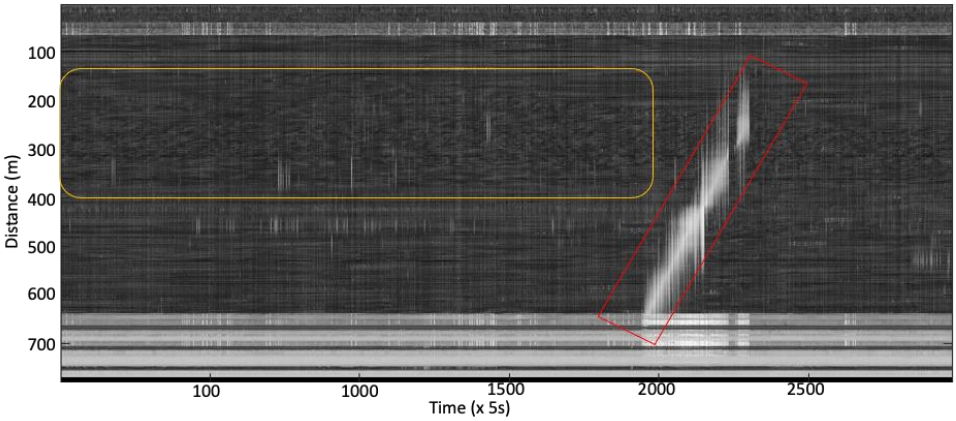

Figure 1: Shows ambient anthropogenic activities captured as a function of offshore distance and time during interrogation of the last 700 m of the seafloor cable at OBSEA, with 0 – 5kHz bandwidth. The red and orange box regions highlight the simultaneous identification of the constituent signals (diver activity and wave motion, respectively) contributing to the ambient marine noise.

The figure 2, which focuses over 0.5 - 1 kHz bandwidth, enables better appreciation of the features in the data, belonging to the region inside the orange box, shown in figure 1.

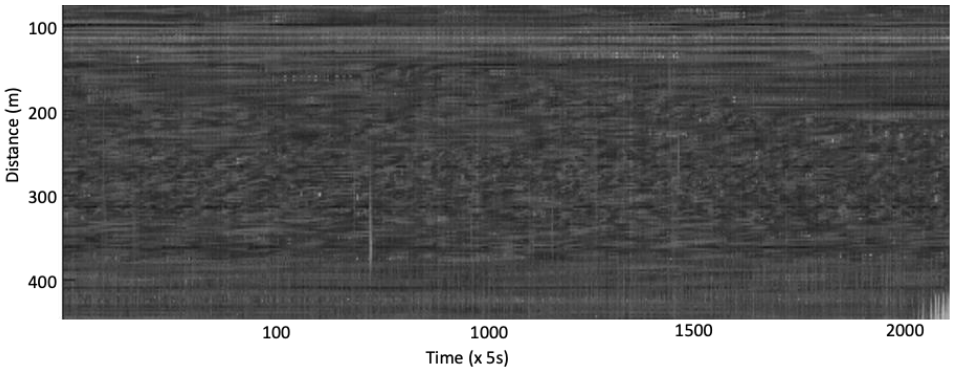

Figure 2: Shows the zoomed in version of the data from figure 1, albeit belonging to the space-time region within the orange box, analysed with frequency band energies corresponding to the 200 – 500 Hz.

[10] Describe in detail results and main findings of your experiment at the present stage.

Figure 3 shows ambient noise (together with identification of some of the contributing signal fields to the noise) over 4 kms of cable length and 0 – 1kHz bandwidth.

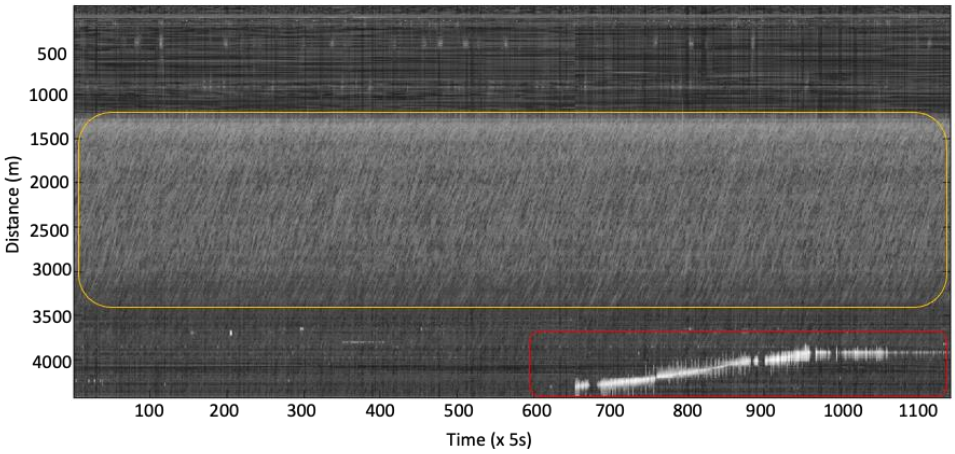

Figure 3: Shows ambient anthropogenic activities captured as a function of offshore distance and time during interrogation of much longer length of seafloor cable at OBSEA, with 0 – 1kHz bandwidth. The red and orange box regions highlight the simultaneous identification of the constituent signals (diver with ongoing repair activities and physical oceanographic motions corresponding to a buried section of the cable, respectively) contributing to the ambient marine noise.

The findings and their ongoing analysis bring us a step closer to realising some of the machine learning approaches which will enable localisation and tracking attributes to be realised, albeit of both natural and anthropogenic activities. The comparative analysis between ambient noise (especially natural noise fields) signatures between exposed (figure 2)and buried (figure 3, orange box section) cable sections should provide insights into the nature of noise coupling and open prospects to examining seafloor too.

Additionally, the variability in the weather pattern, had been found to contribute to the variability in the ambient marine noise content and distribution. This renders the prospects of disentangling several of its attributes through detailed statistical modelling, which is an ongoing investigation, that should ensue tremendous opportunities for enabling development and realisation of novel learning algorithms.

Southampton, 25/5/2022

Location and date

Mohammad Belal

Signature of principal investigator