ABYSOUND, an end to end system for noise impact measurement of deep sea mining production tools

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Abstract— **The aim of the project is to establish the feasibility of a new service and an associated system to estimate the noise radiated into the water by the equipment and systems deployed on the ground during deep offshore sea floor operations. Based on this estimation, the main purpose of the project will be to assess the acoustic environmental impact on marine fauna. It will also make it possible to assess the acoustic disturbance generated by the devices or systems deployed on the ground on the operation of the sub-robots monitoring and implement adaptive strategies to prevent malfunctions of the latter. The project involves technological developments and system validation through deep sea experiments.**

Keywords—acoustic, environmental impact, deep sea mining, underwater noise.

I. Introduction

Mining or oil exploitation of deep-sea subsurface resources (> 1000 m) is expected to develop strongly in the coming years, which will require the deployment of machinery or facilities on the ground (see Fig. 1). The environmental impacts are multiple, and one of them is underwater noise emitted by gear or systems deployed on the bottom, which can create unacceptable nuisances from the point of view of the protection of marine fauna. Indeed, several behavior changes were studied on cetaceans exposed to sound pollution. The potential noxious consequences of noise pollution on cetaceans are:

a) Activity change: Several behavioural changes were studied on cetaceans exposed to sound pollution. For bottlenose dolphins [1] and [2], or killer whales [3], nearby boats cause stress and fleeing. Again, with harbour porpoise exposed to pile-driving sounds, changes from normal activity (stationary, feeding) to traveling was monitored [4]. For any animal, having to flee boats or unfamiliar sounds implies less time for necessary activities like foraging or socializing, and thus smaller access to food.

b) Displacement: As seen in the previous section, cetaceans flee unfamiliar noises. For pile-driving sounds, the impact range goes up to 20 km for harbor porpoise [5]. Vessel traffic showed a long-term decrease of bottlenose dolphins population in the affected regions [6]. Impeaching animals to evolve in potentially crucial areas like feeding or breeding zones can have a heavily noxious impacts on the animals' life. It is thus important to take into account if animals are dependant on a specific area or not to measure the impact of their displacement.

c) Hear loss: Noise pollution induced hear losses (permanent threshold shift (PTS) or temporary threshold shift (TTS)) on cetaceans. Like for humans, the threshold shift describes an augmentation of the minimum sound level needed for sound detection. Studies [1] have measured the sound level onset for PTS and TTS depending on the hearing groups of the marine mammals. Cetaceans rely on their auditory system for numerous aspects of their lives, such as communication (for socializing, organizing hunts and travels, and mating calls), echo-localization, (for navigation, finding prey, and avoiding collisions).

d) Occupation of the acoustic space (Masking): Besides hearing losses, cetaceans auditory capacities can be impeached by the occupation of the acoustic space. Changes of the acoustic behaviour of bottlenose dolphins [7], sperm whales, and belugas [8] have been observed showing, when possible, adaptation techniques against noisy environments. When not possible, acoustic masking can increase energy expenditure and decrease food access and group cohesion for cetaceans [9].

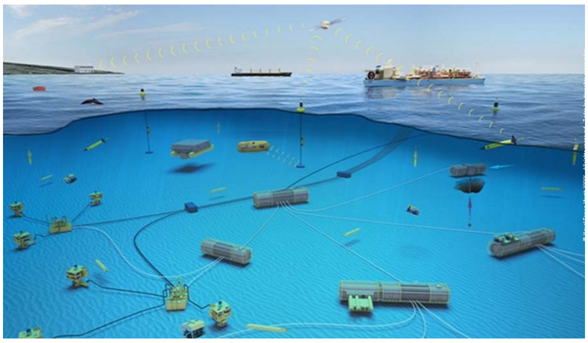

Fig. 1. Artist's impression of an offshore operation (© Naval Group).

ABYSOUND is a collaborative project of 8 participants from small and big industries and from research laboratories: Naval-Group, OSEAN, SEMANTIC-TS, IFREMER, LMA, GIPSA-LAB, MicrodB and LSIS-LAB. It's coordinated by Naval-Group.

The primary objective of the project is to establish the feasibility of an area-deployable submarine system, allowing the estimation of radiated noise emitted by vehicles and equipment deployed on the ground. The functionality of the system is the in-situ direct measurement of the noise radiated in the water by all the noise sources deployed on the seabed or near the bottom. In addition, the development of a bioacoustic impact estimation simulator, including a detailed study of underwater acoustic propagation in interaction with the seabed and the development of underwater noise maps with bioacoustic criteria.

At the same time, a study will be carried out to analyze the impact of radiated noise on on-board acoustic systems of autonomous (surveillance-type) vehicles. The feasibility of an integrated real time system will be studied in order to induce a reaction of the machine to a noise level too high, namely the emission of an alert and/or a strategy of avoidance of the noisy zone.

From 26 April to 2 May 2019, a full concept validation phase was conducted with the deployment of the calibrated noise source (Naval-Group) and prototype acoustic array (OSEAN). Measurements of radiated noise on predefined scenarios were carried out.

The post-processing of the collected information allows:

- Source location and estimation of radiated noise (GIPSA-LAB and MicrodB);
- Estimation of the bioacoustic impact on the local marine fauna, over distances from few kilometers to tens of kilometers (SEMANTIC-TS, LMA, LSIS-LAB);
- Estimation of the noise levels that disturb acoustic systems on board robots or underwater monitors on site (IFREMER);

II. SOURCE AND NOISE CHARACERISTICS

At the moment, we do not have the estimation of radiated noise emitted by vehicles and equipments deployed on the ground, which is essential to properly carry out environmental impact assessments. To realize the project, a study was carried out to define the type of noise radiated by the machines, the architecture of an operation, the technical risks and the constraints for the measuring acoustic array.

A. Environmental risks

The marine and coastal areas are the place of many human activities: maritime transport, renewable energy production, raw materials extraction, fishing, aquaculture, tourism...

Today, anthropogenic underwater noise is considered a major threat to marine wildlife conservation.

Since the effects of noise on the marine environment, and particularly on marine mammals, have become evident, a number of actions have been taken at scientific, political and technical level to address this problem.

The recent Directive Cadre Stratégie Pour le Milieu Marin (DCSMM, 2008/56/EC) [10] specifically mentions the problem of noise pollution and provides a legal framework to address this problem. The Directive is the first international legal instrument to explicitly include anthropogenic underwater noise in the definition of pollution, which must be treated progressively in order to achieve the good ecological status (GHG, Good Environmental State) of European marine waters by 2020.

In this context, tools capable of carrying out acoustic risk assessment and noise monitoring clearly appear to be a fundamental element of a decision support system applied to environmental management.

B. Offshore extraction

Nautilus Minerals, a pioneer in deep-water mining, has obtained operating approvals in Papua New Guinea, Fiji and Solomon Islands, Vanuatu and New Zealand.

For underwater mining, four different families of subsystems are identified:

- SPT : Seafloor Production Tool
- RALS : Riser And Lifting System
- SSLP : Subsea Slurry Lift Pump
- PSV : Production Support Vessel

Fig. 2, for example, shows machinery being built for this deep-sea mining project:

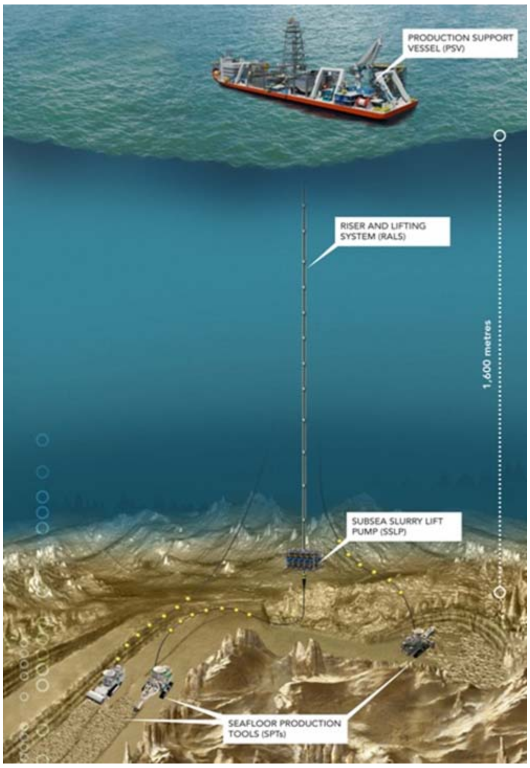

Fig. 2. Plan of offshore mining (© Nautilus Minerals Inc) [11]

All this equipment is derived from the technologies of the offshore oil industry, dredging and mining. For our system (the purpose of which is to characterize the production machines (SPT)) the noise generated by the pumps (SSLP), the riser (RALS) and the FPSO (PSV) on the surface are used in the composition of the ambient noise. The definition of ambient noise will be crucial to predefine the system in terms of measuring dynamics.

In order to define this ambient noise, it was necessary to perform research in order to characterize it. This paragraph will describe the different sources that contribute to the ambient noise first separately. A summation will then be accomplished to estimate the ambient noise at the level of underwater mining.

1) FPSO: A Floating Production Storage an Offloading is a ship-like vessel used by the oil industry for the processing and storage of hydrocarbons. A FPSO vessel is moored in place. It collects hydrocarbons from several underwater wells or production machines lying on the bottom through flow lines. The FPSO has two main noise contributors:

a) Noise generated by onboard activities: Treatment equipment is primarily located on the bridge and under-deck storage facilities. This configuration, along with the fact that FPSOs are generally double-hulled, contributes to limiting engine noise on deck. In the study [12], measurements of FPSO radiated noise were carried out and related to the activities of the ships through their logbooks (injection water production, series of tests on pumps, low-pressure compressor starts, etc.). It is also found that a FPSO can be represented by a monopole source located at a depth of 10 meters and no significant directivity was found for any of the FPSO (by comparing the various data recorded by the different buoys of measure).

b) Thruster propeller cavitation noise: A FPSO usually uses thrusters simultaneously to control its position. In [13], it is indicated that the increase in water depth for oil or mining exploitation caused drilling rigs to evolve towards dynamic positioning systems, rather than “classical” anchor. In Angola, for example, where the weather conditions are good, a dynamic positioning system will ensure that, on a water height of about 1500m, the ship will remain in the desired position to the nearest 1.5m while using anchorages this distance is 15m (10 times greater). Naval Group’s knowledge of the subject as well as research in the literature on the rotation speeds of a DP system (Dynamic Positioning), the number of thrusters, the size of the propellers for a DP, allowed the construction of a cavitation noise gauge of a FPSO.

The noise generated by a FPSO is therefore the incoherent summation of the noise generated by the onboard activities and the noise generated by the cavitation of the DP system thrusters

2) Pump: in the literature, various research studies have shown that the type of pump used in the offshore is mainly multiphase pumps. They are used to increase effluent pressure without upstream separation. In addition, research on this type of pump has led to an order of magnitude of the required power. In article [14] we also find measurements of a dredging vessel. By combining all the information (power, measurements, number of unit pumps, etc.), we built a noise gauge generated by a pump used on a mining operation.

3) Riser : No information on the level of noise radiated by a riser was found. For lack of data, it was assumed that:

a) The noise level of riser for oil extraction is higher than the noise level for this type of application : In fact, in oil extraction, the presence of gas favours a two-phase mixture that generates charge losses on the riser.

b) The noise level of a petroleum riser is "embedded" in the measured noise levels presented during FPSO measurements.

The resulting hypothesis is that the riser noise will be negligible in relation to the FPSO noise levels.

4) Ambiant noise: A used reference acoustic model for underwater ambient noise is the WENZ model [15]. This model consists of the quadratic sum of three components: turbulence in the oceans (very low frequency effect), wave noise related to wind force, and noise from distant marine traffic. We note that for probable environmental conditions on the area (for example Sea State 3 and Average Maritime Traffic) the background noise is not important, compared to the noise levels generated by mining (FPSO, pumps, etc.). The lack of data of ambiant noise of Papua New Guinea will therefore not be critical.

5) Production tools noise: Few data are currently available in the literature to estimate noise levels from underwater mining. Hence the utility of the ABYSOUND project is to propose a characterization system.

To define a gauge approaching the noise radiated by the production machines, we used therefore the few data available for drilling and dredging noise measured in the oil industry mainly, whose mechanism is similar to that used by machines for digging underground mining [16]. Indeed, as with mining on land, part of the noise is expected to come from the impact of the drill on the rock and the vibrations of the ground, and another from the vibrations of the machine [17].

Several comments can be made after research:

- All spectra have the same form and represent a measurement of the radiated noise of a dredging and drilling operation with the noise of a boat (often FPSO type) : a constant value between 130 and 170 dB for frequencies between 10 and 100 Hz, then a decrease of 20 dB per decade.
- Only article [18] gives us an important data because the ship used in these operations has the particularity of being able to land on supports. This way, there will be no cavitation noise from the thrusters. In addition, because the hull is not submerged, the noise of the machinery is not directly transmitted to the water. We note that unlike the other data, in BF (from 1 to 100 Hz) the noise does not seem to contain a peak and the decrease of 20 dB per decade is made from 500 Hz. The BF peak of the other spectra seem to come rather from the cavitation of the DP propellers of the FPSO as well as from the rotation speeds of the various machines and pumps.
- For all spectra, peaks are seen at particular frequencies, certainly directly related to the rotation speeds of different machines and pumps.

The concatenation of all these elements made it possible to build a noise gauge injected into a low frequencies source for our deep-sea tests to test our system of quantification of operating machine.

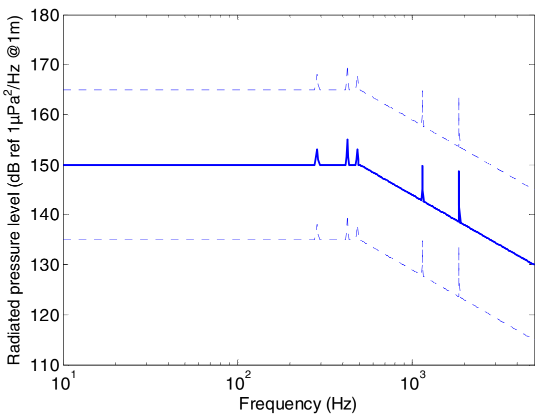

Fig. 3. Estimation of the radiated noise level (dB ref 1 µPa²/Hz) at 1 m of the production tools on the ocean floor as a function of frequency

A low frequencies source was developed in this project by Naval-Group to allow a demonstration test in deep water.

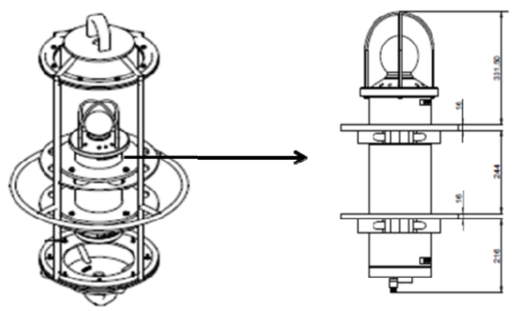

Fig. 4. Plan of Naval-Group's low frequencies source for demonstration testing

This source will generate different signals:

- Pure frequencies signal
- Chirps
- Broadband noise type signal (introduced above) and considered to be representative of production machines

The source also allows to adjust the emitted level to test the array's performance (location and quantification) according to different signal-to-noise ratios. It is important to note that the test frequency band was translated by the geometric homothetic ratio applied to the array (see section III).

III. CARACTERISATION OF MACHINES

A. Acoustic array

Information gathered at the first mining site of Nautilus Minerals (distance and optimum operating level difference between machine and lifting pump, length of riser, etc. [11]) have allowed to define the production of scenarios.

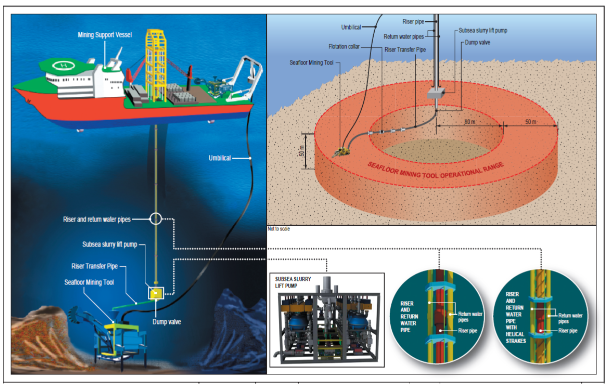

Fig. 5. Explanatory diagram of the working area of a production machine [11]

The anchoring of the measuring array to the ground implies that it is in an area outside the operating surface and the area swept by the links between the machines and the FPSO. Assume more than 50 meters from the edge of the operating boundary.

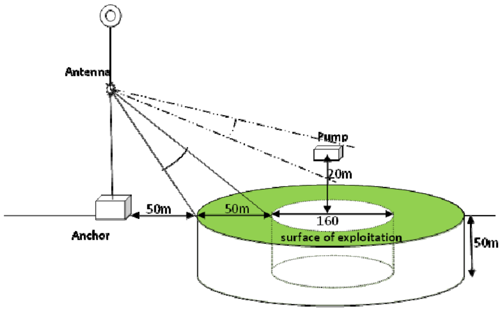

Fig. 6. Dimensional stress for array

Fig. 6 shows that the working area of a production machine will be a ring with an internal diameter of 160 meters and an external diameter of 260 meters. This makes an area of 33000m². It became clear that the scan of such a large area in low frequencies is very difficult. The project therefore set itself an objective of a scan zone of a circle of diameter 100m, which makes an analysis zone of 7850m².

Knowledge of a mining work area and the estimation of the noise levels of each subsystem allowed the estimation of the sound power generated by the subsystem at the array level. In fact, the noise levels of each subsystem (riser, FPSO, pump) being independent of each other, the sources not being correlated, we make the summation of the sound powers of each sub-system to know the total sound power generated by an operation.

$$N_{TOT} = 10\log_{10}\left(\sum_{i=1}^{n} 10^{\frac{Nr(i)}{10}}\right) \qquad (1)$$

With n subsystems and Nr(i) the sound power level of subsystem i at array level.

Thus we have:

$$N_{TOT} = 10\log_{10}\left(\sum_{i=1}^{n} 10^{\frac{N0(i)-20\log(R)}{10}}\right) \qquad (2)$$

Where N0(i) is the radiated noise level of the subsystem I at 1meter and R the distance from the subsystem i to the array.

It is assumed that:

- FPSO subsystem is located at 1500 meters from the production machine and the array,
- The underwater pump is located approximately 180m from the array. Indeed, on the site of Nautilus Minerals, we find that the underwater pump will be placed about a hundred meters from the production machine.

These assumptions mean that the total operating noise level of the production machinery is shared with the level of the underwater pump (in fact, this level is predominant because it is close to operating machines in comparison to the FPSO). It is assumed to be 125dB ref 1µPa²/Hz@1m up to 200Hz and drop of 20dB per decade from 200Hz.

The sound of the pump could even coverthe excavating machines if they are further away than the pump or simply in the main scanning lobe of the array. Scenarios were therefore set up assuming a characterization of the machines near the array and not covered by the pump (cases where the machines are behind the pump).

Parametric and optimization studies were therefore performed (by MicrodB and GIPSA-LAB) to define an optimal acoustic array for :

- pointing toward the ground,
- being invariant by rotation (to avoid anchoring and current rotation problems)
- having a good resolution and dynamic for characterization of the machine

For reasons of manufacturing costs and portability, the project set the number of hydrophones at 48 and at maximum size of 10 meters.

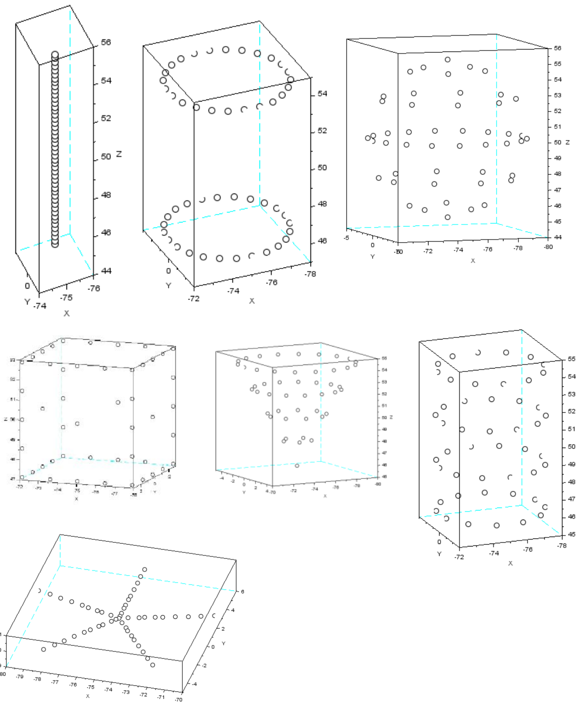

Fig. 7. Various tested shape and design of array

The performance of arrays of different shapes was therefore analyzed and the project selected a conic shape array pointing downward (see Fig. 9). Indeed, its performance will be invariant in rotation, and this array's shape allows to have an average dynamic of 8dB and an average resolution of 50 meters on the frequencies range of interest.

For testing purposes, a small-scale array (3m x 3m x 3m) was manufactured by OSEAN (homothetic x 3.5 compared to the real size). In order to validate the project, a 800 meters deep test was conducted.

To organize the deployment at sea of the calibrated source (Emitting signals representative of the crawlers of the operating areas) and the demonstrator (acoustic array), from an Oceanographic Vessel of IFREMER (R/V EUROPE) see Fig. 8, we had to face the following constraints:

- The R/V EUROPE is a small 30 m long catamaran, the A frame can handle packages with a volume of 3mx3mx3m. This constraint had an impact on the real size of the demonstrator (as previously described)

Fig. 8. Launching the array of OSEAN by the R/V Europe (IFREMER)

- Ensure safe launching and recovery for shipboard personnel so we have to define a step by step procedure to deploy the prototype array (demonstrator) and the calibrated source
- Difficulty in orientation of the prototype array during deployment led to a conical array design (as previously described) ;
- The demonstrator (acoustic array) must be anchored on the sea floor (altitude from the bottom between 50 m and 60 m) and the source must be mobile in relation to this array while respecting the array scanning area, the directivity and the resolution on elevation ;
- The demonstrator (acoustic array) must be able to point to the calibrated source to make measurements, so the source must be near the bottom (altitude about 20 m to 25 m above ground) and must be away from the prototype array between 45 meters and 60 meters ;
- The anchorage lines of the array and the source must be equipped with acoustic beacons (USBL positioning system, accuracy of this positioning is 0.4% of the water depth).

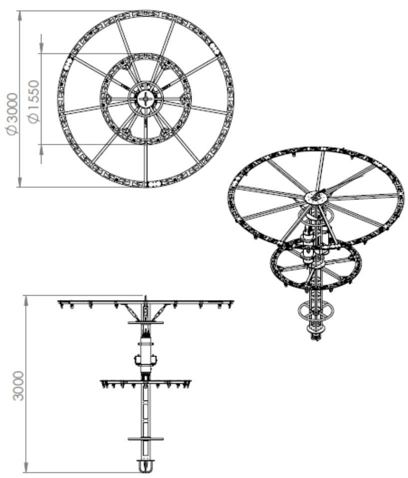

Fig. 9. Plan of OSEAN's array for demonstration testing

At first, from 19 to 22 April 2018, we organized with the R/V EUROPE by small depth (100 meters), the validation of the procedure for the deployment of the prototype array. We added 2 laboratory transducers to simulate noise sources. The verification of the good behavior of the algorithm is given by Conventional Beam Forming (CBF) method to perform localization (Fig. 10).

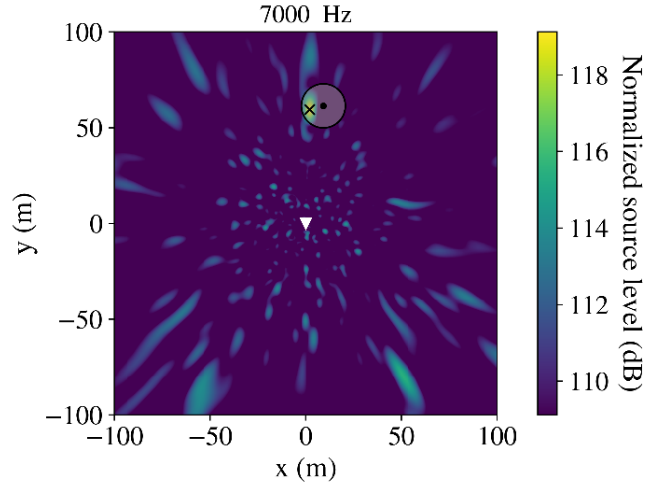

Fig. 10. Localization map computed from the experimental data at 7 kHz. ▼: array position at (0 m, 0 m, 53 m). ●: GPS boat position at (9 m, 61 m, 104m) (104m is the water depth). ×: estimated source position at (2 m, 60 m, 24 m). The uncertainty zone is represented by the whitened circle and has an 11.5 m radius.

B. *Modelling of noise propagation and study impact*

The objective of this task is to implement a digital simulator of the acoustic impact of noise sources with the aim of taking into account as far as possible the complexity of the problem in particular at the source and at the propagation of acoustic waves in the sediment.

To do this, the results of the localization and quantification of the source by the acoustic array will be injected into a propagation model to develop a complete chain capable of solving the problem of acoustic radiation from sub-mining operations to the study of the impact on marine life [19].

This simulator will be a combination from several models: SPECFEM, RAM and RAYSON. SPECFEM (developed by the LMA) is a tool for the complete resolution of the wave equation by including the elasticity of the marine sediment. It is therefore a calculation of underwater acoustic propagation without approximation but having a significant calculation cost. It allows modeling very finely the acoustic behavior in the vicinity of the source as well as the interactions with the sea floor but is therefore limited to the region close to the source and will serve as a starter to the RAM and RAYSON codes able to provide acoustic level maps over long distances.

RAM is a classic code implementing the parabolic equation available on the web. RAYSON (developed by SEMANTIC-TS) is a software that solves the ray equation, simplifying the equation of Helmholtz in the case of high frequencies.

A linkage is carried out so that SPECFEM can provide the initialization data for the 2D simulator, playing the role of 'super starter' of the parabolic model (with RAM). This second model is faster to generate simulations of acoustic losses, but still too long at high frequencies for near-real-time simulations. A second coupling with RAYSON is also carried out so that SPECFEM can provide the level of angular directivity data to initialize the ray code, particularly interesting in terms of calculation time.

A benchmark will be conducted to allow comparison of models to better understand the limits of use of the different models in the case of deep mining operations. This study will emphasize the conditions simplified models (of type parabolic or even rays) that could be used as a first approximation.

The model will make it possible to obtain underwater noise maps by including bioacoustic criteria using the expertise of the UMR LSIS UTLN concerning the impact on marine fauna.

IV. SUB-ROBOTS MONITORING

Underwater mining sites will be monitored using underwater autonomous vehicles. Safe operation of these drones will require a reliable link with the surface using acoustic communication which can be deeply affected by the noisy environment of the mining site. In order to comply with such requirements, the MAR system (short for *Measure, Alarm and Reaction*) has been developed at IFREMER, to be integrated on an AUV vehicle and to allow to measure and identify critical conditions for successful communication. Upon those critical conditions, a warning can be send to the surface and the drone can be automatically steered away from the noisy area to improve communication success rates.

The proposed solution integrates a data acquisition subsea module (Fs=312 kHz) developed in collaboration with OSEAN partner company and a wideband hydrophone. A dedicated real-time signal-processing module has been developed as a C++ distributed application based on the ROS (Robot Operating System) middleware. This latter allows seamless integration on IFREMER underwater vehicles that operate under ROS.

The general operating principle of MAR is described in Fig. 11. The data acquisition module continuously acquires signal from drone environment using a hydrophone that is positioned close to the vehicle's own modem transducer. The signal-processing module implements several signal processing sequential operations on each buffer of the incoming signal. The main operation is to detect the chirp of the acoustic communication message header sent by the surface modem to the drone. The chosen chirp detection method is a Generalized Likelihood Ratio Test (GLRT) [21] and [22]. This choice was done after numerical comparison with other detection methods (Matched filter, Stochastic matched filter, several GLRT approximations). Once the chirp is successfully detected, Signal to noise ratio (SNR) is calculated in the frequency bandwidth of the acoustic communication. Noise estimation for this SNR calculation is computed using noise measurement samples acquired between acoustic communications. The updated SNR estimation is compared against a user-defined threshold whose characteristics are discussed below. In short, whenever the estimated SNR is lower than the defined threshold, the drone control computer sends an alarm to the surface through its acoustic communication modem and commands a maneuver to steer away from the noisy area.

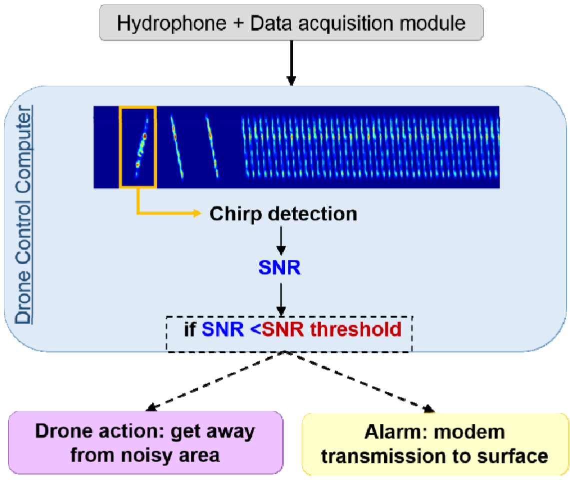

Fig. 11. Operating process of MAR system integrated on a Drone

For testing and validation purposes, the MAR system was integrated on an IFREMER experimental AUV named VORTEX (see Fig. 12). Experiments were conducted in a shallow water environment (harbor with 8 m water depth). The acoustic communication modems used in the experiment were S2CR units manufactured by Evologics and designed to operate in the 48-78 kHz frequency bandwidth. The topside communication modem was deployed along the dock and was programmed to emit a remote message every 5 s; the subsea unit was integrated on the vehicle (*c.f.Fig. 12*) and programmed to transmit a telemetry message every 18 s. The VORTEX vehicle was steered along "isoSNR" trajectories at 5m depth; the trajectories were designed in order to maintain a quite constant distance between the modems.

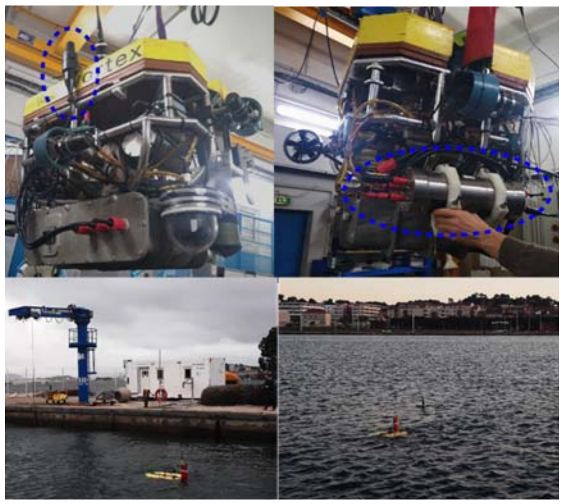

Fig. 12. MAR system integrated on IFREMER AUV VORTEX. Hydrophone and data acquisition module are circled in blue on top left and top right photos respectively. Bottom left and right photos show VORTEX before and after dive

Fig. 13 represents detector behavior, SNR value and alarm triggers during one of those trajectories (~ 225 m distance). Detection process is shown in the top image. Detection values returned by the GLRT are represented as black lines and detection threshold (based on noise variance estimation) as orange lines.

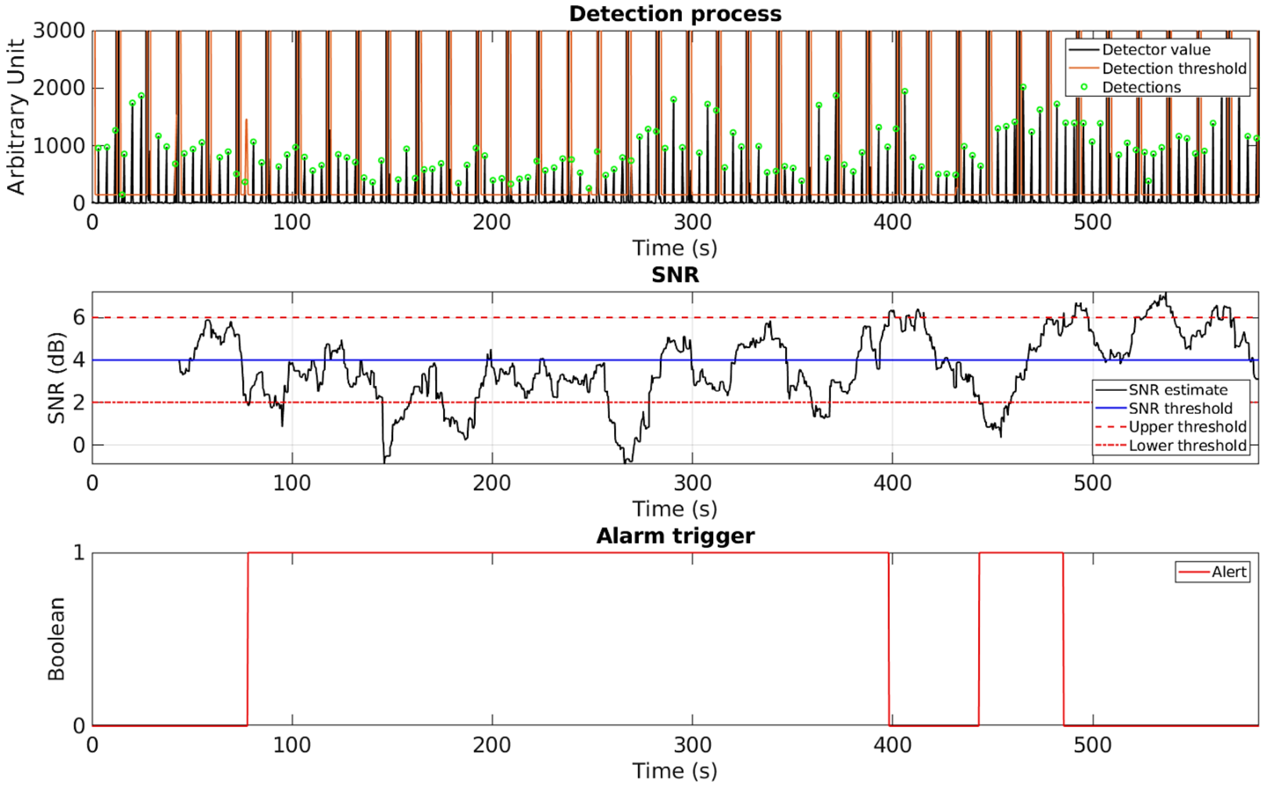

Fig. 13. Representation of MAR signal processing treatment during a dive of the VORTEX AUV. Top: Detection process, Middle: Signal to Noise Ratio calculated on detected modem message header (chirp). Bottom: Alarm triggered by SNR values below Lower SNR threshold

When a detection value is higher than the detection threshold, a chirp is successfully detected (green dots in Fig. 4, top image). However, when detection value is higher than a high level threshold (HL), detection is rejected. This behavior allows avoiding detection from the vehicle's own modem emissions. During the dive represented in Fig. 13, all top-down acoustic emissions not colliding with subsea unit emissions were successfully detected. The middle plot in Fig. 4 shows SNR estimations calculated using average power estimations of chirp detections and noise (black line). The variance of SNR is quite marked on a small timescale. For this reason, it was necessary to implement a numerical hysteresis trigger to increase detection robustness by limiting untimely alarm triggers yielded by a single threshold. Results show that alarms were only triggered twice during vehicle trajectory (bottom figure) for a 4 dB SNR threshold with a 4 dB hysteresis region.

Detection performances, counted by buffer, were studied for all five trajectories (*c.f.* Fig. 14). Detector parameters were optimized to maximize performance and robustness. Two detector parameters configurations were identified and are presented here. The best measured performance indicates a probability to detect the chirp signal equal to 1 and the probability to make false detections was a 10^{-4} order of magnitude as shown in Fig. 14. These performances were obtained even in cases where SNR was measured as low as 1.5 dB.

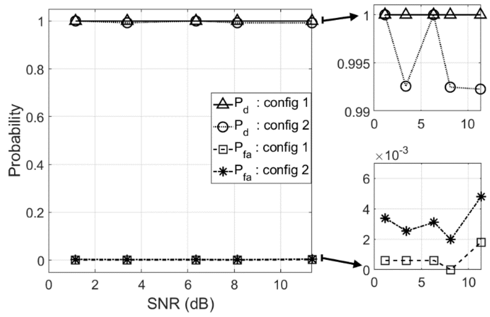

Fig. 14. Detection performances on the five IsoSNR VORTEX trajectories. Detection probability (Pd) and False alarm probability (Pfa) curves versus SNR are presented for two configurations of the detector parameters.

It should be pointed out that detection can be achieved in a noisy environment thanks to the use of a whitening filter on top of GLRT.

In summary, the present study has shown that MAR is a robust system for detecting acoustic communication even in low SNR conditions. These results are very promising for a future use on underwater mining sites.

V. CONCLUSION

The protection of natural resources which has become an obligation since the DCSMM (Marine Environment Framework Directive), adopted by Europe in 2008 [10] and the prevention of damage to marine biodiversity will involve an initial assessment of the environment, the carrying out of environmental impact studies, the implementation of impact reduction measures and periodic environmental monitoring.

The studies are currently being undertaken by state sponsors concerned with this aspect. The situation could however change rapidly and the consequence is that operators or industrialists wishing to exploit the seabed will have to have serious studies, including aspects relating to the acoustic impact on the underwater marine fauna. The project partners will then be able to position themselves on the underwater acoustic impact and measurement market.

With this demonstrator, we will offer the first acoustic measurement and impact simulation system for all developers of machinery and equipmentfor all mining and offshore operators to conduct acoustic impact studies.

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