TRIDENT – Technology based impact assessment tool foR sustaInable, transparent Deep sEa miNing exploraTion and exploitation: A project overview

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***Abstract*—By creating a dependable, transparent, and cost-effective system for forecasting and ongoing environmental impact monitoring of exploration and exploitation activities in the deep sea, TRIDENT seeks to contribute to the sustainable exploitation of seabed mineral resources. In order to operate autonomously in remote locations under harsh conditions and send real-time data to authorities in charge of granting licenses and providing oversight, this system will create and integrate new technology and innovative solutions. The efficient monitoring and inspection system that will be created will abide by national and international legal frameworks. At the sea surface, mid-water, and the bottom, TRIDENT will identify all pertinent physical, chemical, geological, and biological characteristics that must be monitored. It will also look for data gaps and suggest procedures for addressing them. These are crucial actions to take in order to produce accurate indicators of excellent environmental status, statistically robust environmental baselines, and thresholds for significant impact, allowing for the standardization of methods and tools. In order to monitor environmental parameters on mining and reference areas at representative spatial and temporal scales, the project consortium will thereafter develop and test an integrated system of stationary and mobile observatory platforms outfitted with the most recent automatic sensors and samplers. The system will incorporate high-capacity data processing pipelines able to gather, transmit, process, and display monitoring data in close to real-time to facilitate prompt actions for preventing major harm to the environment. Last but not least, it will offer systemic and technological solutions for predicting probable impacts of applying the developed monitoring and mitigation techniques.**

***Index Terms*—impact assessment, technology, environment, deep sea mining, underwater observatories, robotics**

I. Introduction

TRIDENT aims to develop a reliable, transparent and cost-effective system for continuous Environmental Impact Assessment (EIA) and monitoring of exploration and exploitation activities in the deep sea (Figure 1). TRIDENT will develop and integrate technological tools and novel solutions to operate autonomously in remote areas under extreme conditions and provide real-time data to permitting and supervising authorities. These new tools will empower a shared responsibility to supervise and monitor deep sea activities, and simultaneously

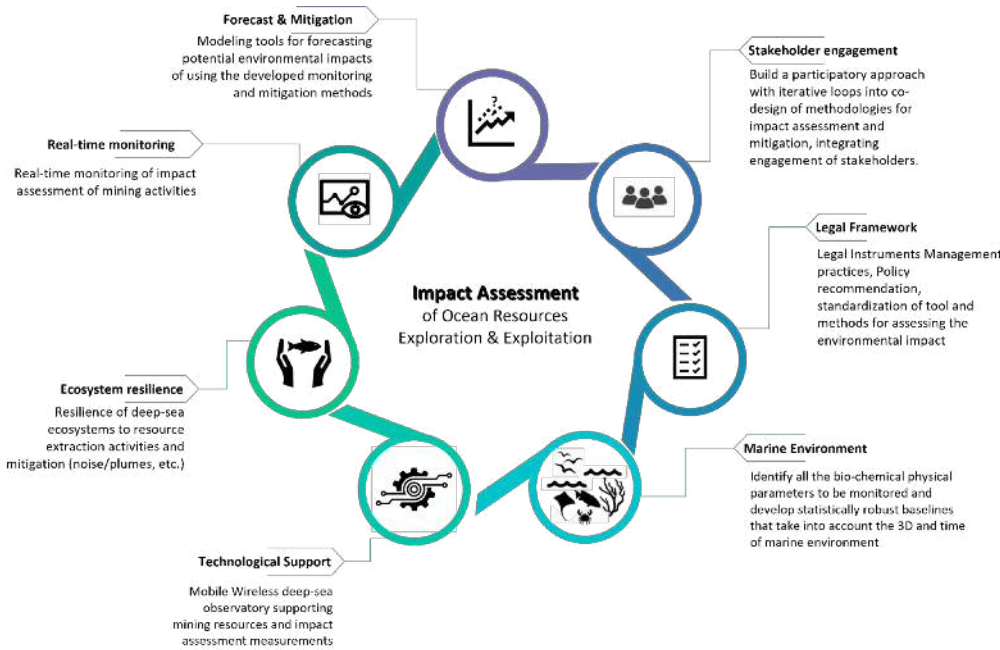

Fig. 1. Holistic approach of Impact Assessment of Ocean Resources Exploration and Exploitation

preserve and enhance marine habitats, supporting an environmentally sustainable blue economy. Among others, the system will allow the assessment of the state of mining operations, the state of ecosystems, and provide forecasts of their short and long-term changes. TRIDENT will also foster the development of mitigation strategies for the negative impacts, or engage an emergency response to severe events such leaks of raw materials in the water column.

Before mining activities can be considered, potential environmental impacts and mitigation approaches must be fully understood. The effective monitoring and inspection system to be developed will comply with international and national legal frameworks, incorporating as far as possible in terms of scope of activities and data acquisition, the International Seabed Authority's (ISA) recommendations for EIA and baseline acquisition [1]. Environmental sustainability and full transparency in the governance of deep sea mining (DSM) exploitation are crucial factors for its social acceptance. TRIDENT will complement all relevant physical, chemical, geological, and biological parameters already known to be measured at the sea surface, mid-water and seabed. The project will also identify gaps in methods of real-time data gathering and build data sets as well as develop technological solutions to address them. These are essential steps to develop statistically robust environmental baselines, establish reliable indicators of good environmental status and define thresholds for significant impact, enabling the standardization of tools and methods. TRIDENT will subsequently develop and test an integrated system of static/relocatable and mobile observatory platforms equipped with the latest automatic sensors and samplers to measure environmental parameters using a DSM simulation and reference areas at representative spatial and temporal scales. This team of relocatable and mobile observatories with autonomous operations, combined with adaptive observation strategies will be critical for a cost-effective monitoring solution with optimal spatiotemporal coverage of the monitoring areas (Figure 2). To support quick actions for preventing serious harm to the environment, the system will implement high-capacity data handling pipelines able to collect, transmit, process and display monitoring data in near real time, INSPIRE[1] compliant and made available through EMODnet[2]. Finally, the project will provide technological and systemic solutions for forecasting potential environmental impacts of using the developed monitoring and mitigation methods.

II. TRIDENT'S OBJECTIVES

TRIDENT proposes to progress beyond the current state-of-the-art (SoA) by filling technological limitations and data gaps, establishing advanced methodologies for real-time monitoring of environmental impacts and providing mitigation measures in the context of DSM (polymetallic sulphides, ferromanganese crusts and polymetallic nodules). TRIDENT will provide a wireless fixed and mobile (modular) network of sensors and autonomous robots for real-time environmental monitoring and data transfer from the deep remote ocean to shore, validated in relevant scenarios. TRIDENT's solution architecture will allow the definition of the variables (and their frequency) to be monitored, as well as their representation in different spatial and temporal scales. The long-term effects can be estimated based on studies to be carried out during the project's 5 years.

III. THE PRESENT *vs* THE FUTURE WITH TRIDENT

The following sections detail the current state of the art in DSM monitoring and mitigation, and compare this with the aspirations of TRIDENT.

[1]https://inspire.ec.europa.eu/
[2]https://emodnet.ec.europa.eu/

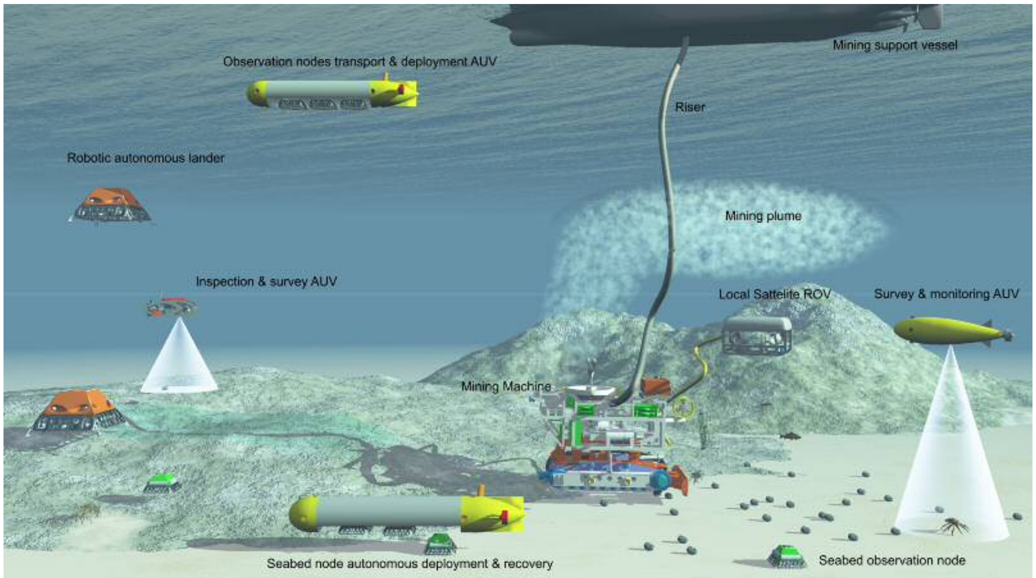

Fig. 2. Artist's rendition of TRIDENT's *in-situ* test

Network Observatory

Observatories are platforms equipped with multiple sensors, placed along the water column and on the seafloor. Deep sea observatories are now relevant key tools to understand the ocean and the complex physical, biological, chemical, and geological processes taking place at sea-floor and evolving steadily over the last decades by means of programs and projects based on new instrumentation and permanent underwater networks. Global prominent initiatives are: The Ocean Networks of Canada (ONC)[3] operating world-leading ocean observatories and offering unique scientific and technical capabilities where researchers access free data globally, in near real-time. The Ocean Observatories Initiative (OOI)[4] is a science-driven ocean observing network that delivers real-time data (free and online) from more than 800 instruments to address critical science questions regarding the world's oceans. EMSO-ERIC[5] (a TRIDENT partner), is formally a legal framework created for pan-European large-scale research infrastructures consisting of a system of regional facilities at key sites around Europe and offers data and services to a broad group of users, from scientists and industries to institutions and policy makers, providing relevant information for defining environmental policies based on scientific data.

TRIDENT's Upscaling on Observatory Architecture

State-of-the-art observation networks still base their observation network on sets of sensors installed at fixed points, mostly wired or connected to host facilities via satellite. Some of these networks already collect information using sensors mounted on mobile underwater systems or vessels of opportunity. The architecture and elements of such networks are unable to understand phenomena on a regional scale and of a generic nature. TRIDENT's system will comprise a lightweight, wireless and relocatable observation network, formed by stationary smart sensors and mobile heterogeneous underwater platforms. This is a smart Multi-Asset system, self-adaptable in response to the environmental changes, capable of collecting and processing *in-situ* observations relevant to DSM activities whilst aiming at efficiently monitoring the complex and dynamically evolving environmental impact arising from DSM activities.

Impact Assessment Architecture

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To date, there has been no significant impact from DSM for the simple reason there has been no major or sustained DSM activity [2]. Studies conducted to date have largely focused on environmental baseline surveys (MIDAS - Managing Impacts of Deep-seA ReSource Exploitation[6], 2013-2016 and JPI Oceans Mining Impact projects, MININGIMPACT[7] and MININGIMPACT2[8] - 2015-2017) to identify habitats, ecosystems, biotopes and species, and assess their vulnerability in response of assumed and predicted levels of disturbance that may arise from mining. Very few studies have been made where actual mining disturbance was simulated [3]: the JPI Oceans project studied the dispersal of sediment plumes arising from dragging benthic nets across FeMn nodule fields, and two studies generated plumes with better constrained source terms. The MarineE-tech[9] project generated a benthic plume in 2016 on a cobalt-rich crust gyot in the NE Atlantic. The PLUMEX[10] experiment generated a shallow pelagic plume by discharging sediment and tracers at the sea surface in the Pacific. More recently, industry has attempted to explore and model the

[3]https://www.oceannetworks.ca/
[4]https://oceanobservatories.org/
[5]http://emso.eu/
[6]https://www.eu-midas.net/
[7]https://www.jpi-oceans.eu/en/miningimpact/
[8]https://www.jpi-oceans.eu/en/miningimpact-2/
[9]https://noc.ac.uk/projects/marinee-tech/
[10]http://www.mod.ucsd.edu/plumex/

impacts of sediment plumes by observing plume particle density at the source using acoustic and optical backscatter sensors mounted on prototype mining machines. All these experiments looked at the proximal impacts of the plumes over length-scales of tens to hundreds of metres and some (MarineE-tech and PLUMEX) were used to better constrain numerical plume dispersion models. A holistic approach to studying mining disturbance in which a variety of phenomena are physically simulated at the same time, including sediment plumes, noise, light and dissolved chemicals is needed. Also, to date, no physical simulation was made that measures and quantifies the near, medium and far field disturbances together. Hence the importance of identifying the generic disturbances that may arise from mining each of the three different major seafloor mineral deposit types, devising the technologies, methodologies and systems to monitor them, and simulating them *in situ* in a deep-sea environment.

TRIDENT's Upscaling on Environmental Impact Assessment

A holistic approach to monitoring DSM impacts requires several key components: knowledge of the critical parameters to be measured; the time and length-scales over which these should be measured; the key technologies required for *in situ* monitoring; communication of the data at the appropriate rate; and modelling to ensure the critical data update forecasts that can then be used as early warnings as part of a systems based mitigation strategy. TRIDENT intends to deploy domain specialists to identify the key environmental parameters to be used to measure those impacts already identified by international and national regulations, and identify key proxies for those impacts that can be measured reliably over a range of time and length scales. Technologists will then be brought together with the domain experts to identify both existing and new sensors and their integration on both mobile and fixed platforms to measure and communicate critical measurements where they will be incorporated into numerical/digital models of the ocean environment, allowing for forecasts of impact dispersal to be calibrated and updated. This approach, first developed within a theoretical framework, will then be used to inform the design of an integrated and holistic monitoring system to be demonstrated at a deep-sea site, already well characterised in terms of its hydrography and biology. The outcome will be a blue print for future monitoring systems for DSM that will inform operators and regulators of past and current impacts, and forecast near-term changes in those impacts to enable operators to mitigate against harm by altering their extraction activities. All data collected during TRIDENT experiments will be shared in Ocean twins data lakes to be used by other scientists.

Development of a Semi-Autonomous Resident Fly-out ROV (RF-ROV) for Inner Circle DSM Activity Monitoring

Close proximity to mining machinery presents an extremely hazardous and challenging environment for operation of semi/autonomous vehicles. Whilst touchdown support, drilling, cable/pipeline laying/trenching ... are beyond the capabilities of fully autonomous systems, therefore requiring semi auto ROVs with human intervention. Fully autonomous AUVs are not suitable for interventions and only exist for remote monitoring. On going resident ROV development for monitoring in Oil&Gas installations is under investigation and development at the moment, and fully operational deployed commercial solutions are not widely rolled out [4], [5].

TRIDENT's Upscaling for Semi-Autonomous RF-ROV in Inner Circle DSM Activity Monitoring

To provide monitoring capability in the hazardous environment close to the DSM robot, TRIDENT will develop a RF-ROV as a monitoring system, to be integrated into the DSM mining robot system. This system will offer the following advantages beyond the SoA: a) the monitoring platform will rest with the DSM robot, accessing a larger power source (through DSM umbilical) hence powering a larger sensor payload (such as HD cameras, imaging sonars, lasers, and other dedicated sensors developed within TRIDENT); b) using the DSM umbilical for the fiber-optic communication, high-bandwidth critical data will be exchanged between surface control and the underwater systems (e.g. allowing for the re-calibration of high fidelity plume dispersal models that will then provide inputs to the underwater plume tracking system).TRIDENT will also develop a Tether Multipoint Management System (TMMS) easing the positive control of RF-ROV tether for operating around the DSM robot without collision.

Underwater Communications

1. Current commercial solutions for underwater networking only support simple network topology and single vendor devices [6]–[8] and are not adequate to support: 1) more complex topology, e.g., mesh network, which, along with multiple-hop routing ensure greater area coverage; and 2) multiple vendor devices as envisaged by TRIDENT scenarios which foresee the cooperation of multiple assets. 2. Regardless of the different solutions proposed in literature, presently, using a single networking solution cannot offer a consistent and stable behaviour in the different operational scenarios and has motivated the paradigm shift from a standard monolithic communication stack to an open, cross-layer and modular Software Defined Communication Stack (SDCS) [9]. 3. In the scope of multi-hop communications, routing protocols have been extensively investigated in literature. Among the proposed routing solutions, there are protocols based on single-path [10], [11] or multipath [9], as well as routing protocols that use geographic or partial geographic information [12]. Solutions based on machine learning approaches have been proposed, such as CARMA [9] offering high reliability, low latency and energy consumption. The protocol uses a distributed reinforcement learning algorithm to switch adaptively between single-path and multi-path, trading off performance for reliability and energy consumption. But solutions like CARMA are limited to simple sensor network scenarios with homogeneous traffic and single destination (sinks).

TRIDENT's Upscaling in Underwater Communications

1. TRIDENT underwater sensor network will support mesh topologies which ensure greater performance, reliability, and

area coverage. Along with its software defined capability and adaptive networking capability, TRIDENT underwater sensor network will cater for interoperability among multiple – possibly heterogeneous – assets, as requested by TRIDENT scenarios. 2. TRIDENT will develop SDCS underwater wireless network with self-adaptation at each layer of the SDCS, dynamically adapting the protocol stack configuration to optimise the performance according to the actual scenario in a distributed way to achieve the global optimum. In addition, it can dynamically choose the best transmission technology to be used in innovative multi-modal system according to the application scenarios, Quality of Service (QoS) and environment constraints. The adaptive SDCS multi-modal system can truly improve the performance of the current solutions, increasing the robustness and the reliability of the system, thus enabling the underwater communication between underwater assets, both mobile and static. 3. Apart from existing solutions, TRIDENT's underwater wireless network communications, will provide an adaptive set of protocols for network wide QoS support and optimization, to efficiently provide adaptive mission planning, sensing and reporting in ever-changing scenarios. A key ingredient will be the use of software defined protocol stacks developed by WSENSE Srl for supporting QoS primitives at the routing, link and traffic scheduling level, and the use of decentralised adaptive lightweight learning algorithms to adjust network behaviour as environment and mission requirements change over time.

Infrastructure for underwater navigation

Today's deep sea positioning systems are mostly sea bottom fixed structures, where their deployment/recovery requires time consuming operations and additional logistic resources that result in huge operation costs. This traditional approach of building a capital and operationally expensive grid of multiple fixed observation points cannot meet the requirements of dynamic reconfiguration and adaptation to a deep sea mining ever changing scenario.

TRIDENT´s upscaling with a dynamic infrastructure for underwater navigation, monitoring, energy transfer and storage

This innovative infrastructure will overcome the limitations of state-of-the-art acoustic underwater positioning systems in a dynamic deep sea mining environment since remote relocatable systems will be able to locate and reposition themselves providing high accuracy position and navigation of machines and impact assessment equipment. TRIDENT's underwater reallocate landers will operate with dynamic remote awareness *in situ*, absolute geo-reference capabilities and decentralized underwater communications solutions. These self-adjust/or reallocate landers will support the dynamic awareness sensing network. In terms of energy, several advanced solutions for sensor powering will be created so that efficient wireless power transfer technology (WPTT) becomes a reality for deep sea environments. TRIDENT will ensure the implementation of solutions for the physical layout of the WPTT bidirectional antenna subsystem inside the underwater platforms (AUVs, ROVs, and landers), implementation of novel adaptive antenna matching/frequency tuning circuits and the implementation of a bidirectional WPTT battery charging subsystem.

Novel In-Situ Sensing Capabilities - Examples

1. Sediment settling is usually measured with sediment traps. Their design affects the local hydrodynamics and prevents re-suspension of particulate, overestimating sedimentation rates [13] and providing an accumulated measurement rather than time-dependent data. Some attempts have been made to improve the SoA, either with real-time imaging of deposition (requiring multiple carefully-placed components [13]) or by measuring backscatter on a sediment collecting plate [14]. These techniques, while promising, have only been applied to devices using a single technique in shallow water ($<10\,\mathrm{m}$), primarily coral reefs. 2. Eh or oxidation/reduction potential (ORP) sensors have been explored for the detection of hydrothermal vents, an analogous task to plume tracking in a DSM context. To date this has only been done with custom-made instruments which are not commercially available [15]. A few commercial ORP sensors exist but are not suited for autonomous deployments in DSM contexts; for example, the SBE27 [16] (nearly $40\,\mathrm{cm}$ long) has a limited depth rating and must be deployed vertically (not practical in a vehicle). Other instruments (e.g. from Yokogawa [17]) are designed for terrestrial process monitoring and are not submersible beyond a few metres of depth. 3. To convert platform capabilities into data, autonomous sensors are required. Commercial biogeochemical instruments are limited to a few parameters (e.g. pH, oxygen, nitrate, phosphate) and often cannot be used to full ocean depth, or suffer from long-term drift [18]. Integrating novel sensors from various suppliers into vehicles is often a complex and time-consuming process.

TRIDENT's Upscaling in Sensing Capabilities

1. TRIDENT will develop a fully autonomous, optical sediment trap, designed to operate at full ocean depth, enabling its use in DSM. It will use multiple modes of measurement which allow a higher range of sediment deposition to be measured, increasing the deployment lifetime of the instrument (crucial for inaccessible environments). 2. An oxidation-reduction potential sensor will be developed for TRIDENT, targeting the ultra-miniature size ($<20\,\mathrm{cm}$ length) and low power requirements for integration into autonomous platforms. Real-time communications will allow the sensor data to be used in vehicle decision making. This system will use the same electronic and mechanical architecture as the existing ultra-miniature conductivity, temperature, and dissolved oxygen sensor developed at NOC, offering small, low-power, and interchangeable sensor packages. The system will be rated to full ocean depth ($6000\,\mathrm{m}$). 3. Autonomous lab-on-chip sensors such as those developed at NOC are SoA for *in situ* biogeochemical analysis. TRIDENT will take advantage of existing efforts to integrate these sensors into autonomous vehicles. Lab-on-chip sensors for >10 biogeochemical parameters have been already developed, including nutrients [19] and pH [20]. As these sensors share a common hardware platform the project can flexibly select sensors for the key parameters identified, minimising integration efforts.

Adaptive Sample & Plume Track

1. AUVs in challenging real-world applications have currently little or no embedded autonomy and typically follow a set of predefined way-points [21]. 2. Plume boundary search missions are often limited to lawn-mower patterns for covering space and obtaining *in-situ* measurements, then processed offline (after vehicle recovery), where mission adaptation usually also takes place. The vehicle is then redeployed to perform a finer survey, essentially creating an iterative process that lasts until mission objectives are met (if possible). 3. When *in-situ* control is instead required, it is mainly in the form of basic search actions based on certain environmental thresholds in comparison to the background levels [22]. 4. Gradient-based algorithms have also been used providing some level of online mission adaptation, but still with known limitations [23]. 5. Existing plume tracking techniques can often be insufficient to capture rapidly evolving phenomena due to the delays introduced in (2.); or the degraded performance of (3.) and (4.) when obtaining too noisy measurements. Also, in the presence of turbulent diffusion, plumes are likely to exhibit an intermittent patchy distribution that can make (4.) sub-optimal. 6. Current AUV plume tracking applications are often limited to a single agent, thus affecting mission length or introducing spatial uncertainties due to inadequate space coverage. But, when using Multiple Agents, vehicles are often ignorant of the presence of others (no communication), or have little communication due to the associated challenges. As such, applications are limited to a small number of platforms with little interaction (e.g., one-way leader to follower(s) communication for coordinated control, rather than sample-based adaptation) in environments favourable to underwater communication.

TRIDENT's Upscaling in Adaptive Sample & Plume Track

TRIDENT will develop an intelligent MA plume tracking system to determine the spatial extent of DSM plumes. This MA system will consist of multiple deep rated long-endurance (months) AUVs [24] and gliders fitted with advanced sending and providing complementary motion/observing capability for efficient space coverage. TRIDENT will develop optical sediment trap devices, integrated with low-power acoustic modems, that will be optimally distributed at the bottom of the ocean to provide real-time information about the sedimentation level. The MA system will communicate using a dedicated robust acoustic communication infrastructure, hence forming an underwater sensor network. Due to the hazardous conditions near the DSM robot, the inner circle of the plume tracking system will be achieved using a RF-ROV monitoring system. With the fiber-optic communication through the ROV's umbilical to the surface mining support vessel, high-bandwidth critical data will be streamed to the surface control. Shore/ship-based high fidelity plume dispersal models (developed in TRIDENT) will be calibrated using *in-situ* observations available in real-time (e.g. from the RF-ROV) to provide accurate forecasting of the plume evolution. TRIDENT will develop an efficient multi-level plume tracking system that provides: a) autonomy engine that performs data fusion to estimate the plume spatial extent and coordinates the MA system (by providing opportunistic mission updates to the smart network of robots) based on the continuously updated plume model; and b) onboard robot autonomy that using classification (plume vs background) and AI will provide local behaviour adaptation based on *in-situ* observations and information shared across the network (e.g., estimates of the water flow and of plume geometry, sedimentation level, etc.).

Noise Sensor Systems

Ocean sound was recently declared as an Essential Ocean Variable (EOV) by GOOS[11] and a new chapter on ocean noise inputs was included in the World Ocean Assessment II report published by the UN in 2021 [25]. There is now a wide scientific consensus that anthropogenic underwater noise is recognized as a major threat to marine life [26], [27]. Studies for ocean sound level worldwide strongly correlate its increase with that of ship traffic and GDP over the last six decades at a rate of approximately $3\,\mathrm{dB/decade}$ (which means multiplied by 2 every ten years) [28]. Ocean noise is normally classified in two categories: continuous noise - normally ubiquitous and low level (e.g. shipping noise), and impulsive noise - normally of high or very high intensity but of short duration and localised in space (seismic surveying, Oil&Gas exploration, sonar, etc). The noise generated by DSM belongs to the latter category, yet there is a clear knowledge gap regarding the nature of DSM generated noise. Available data on noise emissions from DSM mining equipment is very scarce and coming from reduced size-scaled prototypes.

TRIDENT's Upscaling in Noise Sensor Systems

DSM is a recent activity with potential direct impact on the ocean benthic ecosystem, but also on the water column because of noise and sediment plumes. The challenges faced by DSM noise monitoring may fall into the following categories: (1) lack of knowledge about the intrinsic characteristics of the activity, such as source level, frequency, directivity, ground or water column excitation components; (2) coupling into the water column and propagation in the surrounding area - which is strongly related to the characteristics enumerated in (1); and (3) additional noise generated by support ships and other platforms either during materials retrieval, ore filtering, etc, or during area surveying (sonar, seismic, coring, etc). Innovative aspects related to (1) are those of obtaining short range noise characterization but also that of measuring the particle motion field through the water and seabed; classically noise is generated at the sea surface and propagates to the deep ocean, in DSM it's the opposite, while if the right frequencies are excited, noise spatial spread may be quite large on the order of tens of kilometres. TRIDENT intends to deploy *in-situ*, mid and long range fixed water column acoustic recorders as well as a set of acoustic gliders to capture noise distribution in the area before and during DSM activity, for setting up data calibrated noise models and establish accurate excess noise levels, a must for deriving meaningful noise pollution indicators and support ocean noise management policies.

[11] https://www.goosocean.org/

DSM Mitigation Strategy

Today, there is no Noise Mitigation System and no turbid plume containment system for great depths because this need does not yet exist but is fastly emerging for Oil&Gas subsea factories and for DSM. To contain turbid plume, floating geotextile and/or PVC curtains are often used but only for the first few metres above the sea floor surface. To contain the underwater noise, almost all the solutions used today are based on the impedance change between air and water [29], [30]. A layer of air is therefore introduced to reduce the noise, either in the form of bubbles (bubble curtains), air balloons attached to a net (HDS), cofferdam (IHC) or on membrane (SubSea Quieter from GREENOV). However, air is only acoustically effective to a depth of a few hundreds of metres, as the pressure associated with depth ($+1\,\mathrm{bar}$ per $10\,\mathrm{m}$) compresses strongly the air and thus the air/water impedance break is greatly reduced. All the air-based technologies are therefore not viable at great depths.

TRIDENT's Upscaling in DSM Mitigation Strategy

The only viable solution for DSM would be to use solid or viscous acoustic metamaterials, but no studies have yet been made on the use of this type of material at these depths. First applications have been developed for pile driving (AdBm resonators boxes). However, TRIDENT's partner, GREENOV is already working on this topic for Oil&Gas applications at depths of $1000\,\mathrm{m}$ to $2000\,\mathrm{m}$ and already has a metamaterial concept for these deep applications.

IV. Conclusion

The TRIDENT project started in early January 2023 and is evolving at a steady, consistent pace and working to ensure that in five years time, the technologies envisaged by the project will be ready to become part of the new paradigm in ocean monitoring systems.

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