Deliverable report -RiOMar Project

Task	- Date due - Date of report	Deliverable number and title:	Person in charge
6.1.1	- Mars 2024 - 4 mars 2024	D6.1.1: Design of the high-frequency instrumented mooring	Bruno Deflandre

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Abstract: The 2D Observatory Station (2D-OS) is an adaptation of the Mastodon-type systems (i.e. an *in-situ* monitoring system that records the temporal variation of temperature in the water column and near the bottom) to the high-energy conditions of the WGMP. The objective is to deploy several moorings simultaneously to obtain high-quality data with high temporal and spatial resolution to describe seasonal hydrological and biogeochemical changes. The main developments are to: (1) modify the morphology and weight of the structure to improve its offshore stability, (2) add an acoustic release system and a line mooring system to trigger the mooring line upon request and recover the 2D-OS, (3) equip it with different types of sensors (e.g. T, S, O_2), and (4) add a safety float. The specifications and the design of the 2D-OS system are described in detail.

DELIVERABLE REPORT :

INTRODUCTION

The West Gironde Mud Patch (WGMP) is a RIOMAR system located on the mid-shelf of the Bay of Biscay where the hydrodynamic is favorable to Gironde-derived sediment deposition, surrounded by sandy sediments. The WGMP is a depocenter for muddy sediments, carbon and associated contaminants. Biogeochemical transformations are exacerbated by seasonal bottom water deoxygenation, organic matter inputs (bloom, flood), and sediment resuspension during increasingly intense and frequent storms. The WGMP geochemical and ecological status and functioning are still poorly understood, due to the lack of observation in this challenging area. WP6 aims to address its vulnerability in response to Global Changes (reduction of Gironde discharges, increase of summer stratification and storminess) while providing the dataset required to calibrate the regional model (WP3). This implies to (6.1) develop a first continuous monitoring of the water column, (6.2) document the long-term coevolution of the targeted biogeochemical and biological descriptors and hydrodynamics in both the water column and sediments, and (6.3) track the long-term morphological evolution of the WGMP. In this context, the task 6.1.1 consists in adapting the MASTODON tool (Lazure et al 2015, 2019) to the highly energetic conditions prevailing in the WGMP (tides, swells, waves, storms). This deliverable report presents the design of the high-frequency instrumented mooring that will be deployed in the WGMP from October 2024. After a brief overview of MASTODON-type systems, we present the specifications and the choices made, and the description of our 2D Observatory Station.

DESCRIPTION OF THE MASTODON-2D

The MASTODON-type system has been previously described in detail elsewhere (Lazure et al 2015, 2019; **Figure 1**). Briefly, the first version of the MASTODON was a near-bottom platform that included a temperature logger with ballast and a release device based on a burn wire. However, this design required the recovery date to be define precisely prior to deployment, which is challenging to predict when working offshore. The original design was then modified by adding a mooring line equipped with temperature and pressure loggers to monitor both the column water (from 10 m below the surface) and the bottom water, resulting in the 2D version (time –depth).

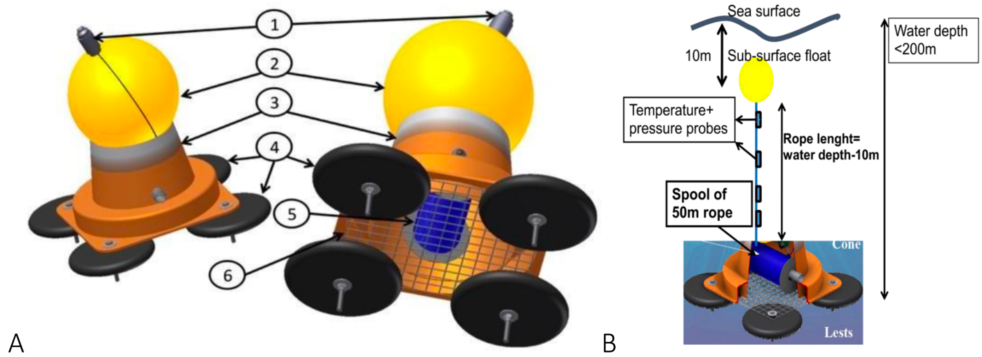

Figure 1. A : Scheme of MASTODON including its 1-electronics, 2- float, 3- traffic cone frame, 4- ballasts, 5- rope spool, 6- wire grate (Lazure et al 2015). B : Conceptual design of the Mastodon2D (Lazure et al 2019).

DESCRIPTION AND SPECIFICATIONS OF THE 2D OBSERVATORY STATION

The basic idea behind the MASTODON was to design a low-cost, lightweight system that could be deployed and retrieved from a small vessel without the need for lifting gear. This concept has proved its suitability in littoral environments (e.g. the Bay of Vilaine). However, the WGMP is subject to high swells, strong tidal currents and winter storms, raising concerns about the potential inadequacy of the classic mastodon. Although based on the innovative MASTODON systems, the 2D Observatory Station has additional specifications to match the requirements of offshore applications in the WGMP.

1/ A lightweight mooring adapted to the highly energetic conditions prevailing in the WGMP: The first constraint is to have a structure that is light enough to be deployed/retrieved by a small vessel, but also heavy enough and well anchored in the sediment to remain in place during high energy events. The design of the 2D-OS has therefore been completely rethought compared to MASTODON-type systems. Based on previous experiences on in situ profiler and eddy correlation, we have chosen a triangular frame equipped with 3 large drop-shaped feet (to limit the burial), which are adjustable in height (approx. 15 cm) and extend 10 cm laterally from the main frame. This increases the base and wheelbase of the structure, providing better anchorage (improved stability) in the sediment. It is made of stainless-steel (A4 quality) with 10 mm thick parts and tubes with an internal diameter of 40 mm. The original plastic drum of the *Dyneema®* rope has been replaced with a stainless-steel drum mounted on the structure to provide extra strength and stability when the structure is recovered. All parts of the 2D-OS are drilled to provide multiple mounting options for the various sensors. The frame was built by CSM 33 (manager: Loïc Bouillard) in Bègles.

2/ A reliable and affordable release system triggered upon request: The choice of using a subsurface buoy of the MASTODONs systems has been kept because it enables to limit issues during the storms or fishing activities. The buoy is located 10-15 m below the surface, allowing most ships to pass over it. This implies to use a release system that allows the buoy to rise to the surface for retrieval. As sea conditions are generally unpredictable over several weeks/months (e.g. the Bay of Biscay in autumn 2023), it is essential to be able to trigger the release mechanism on demand. Thelma Biotel (TB) proposes an affordable acoustic release system, TBR 800 Release, with a battery life of up to 24 months. It has a motorized remote release function. The release command is sent as acoustic signals from the TB DeckBox surface control unit on the boat. The TBR 800 Release uses a mechanical release system where a motor physically drives off a release lug. This is a robust and reliable mechanism. Received data is stored in internal memory, along with logged temperature data, noise conditions, tilt, power consumption, and battery status. The distance-ranging function of the DeckBox makes locating the TBR 800 Release easy and efficient. In addition, a Focus - Directional amplifier kit (an acoustical reflector) can be fixed over the live transmitter to increase the range with the DeckBox and to provide a bearing

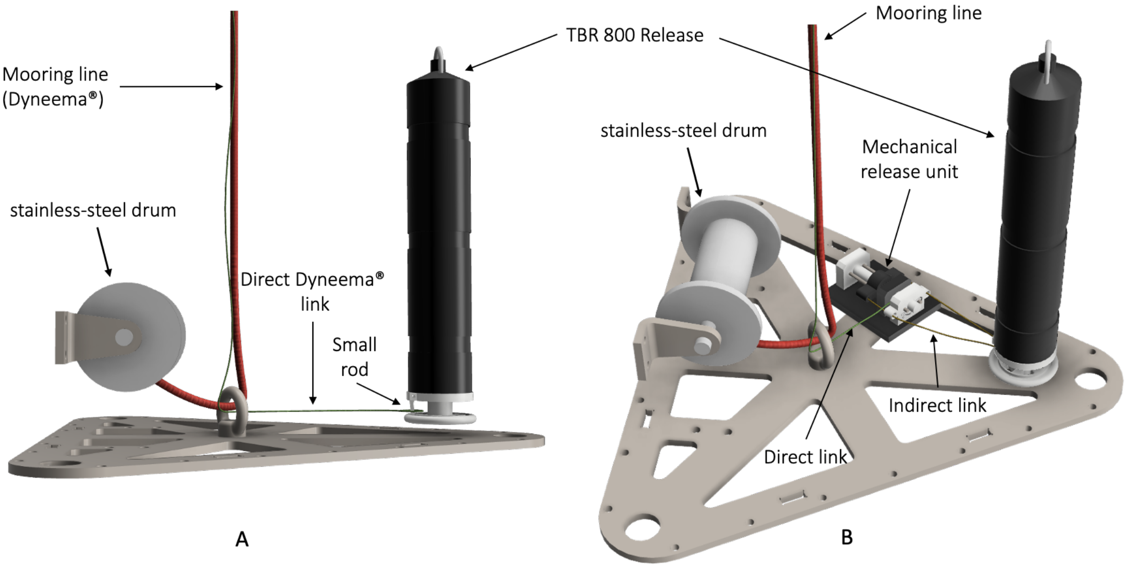

Figure 2. Scheme of the release of the mooring line. A : Configuration IFREMER with one direct *Dyneema®* link between the acoustic release system and the mooring line (Pairaud, pers com). B : Configuration EPOC with two *Dyneema®* links : a direct link between the mooring line and the mechanical release unit mounted on the structure, and an indirect link between the mechanical release and the small rod of the acoustic release system.

for the direction of an acoustical transmitter. The Pascal Lazure's group (LOPS, IFREMER) has successfully experienced this release system in recent years using a direct *Dyneema®* link between the mooring line and the small plastic rod of the acoustic release system (**Figure 2A**). However, we are concerned that the high hydrodynamics in the Bay of Biscay will put too much strain on such a small rod. Although we have enlarged this part, we have developed a *Niskin*-type mechanical release system that is fixed to the structure (**Figure 2B**). This has the advantage that the mooring line is now connected directly to the mechanical release unit which is fixed to the structure, rather than to the small rod of the acoustic release system. With this configuration, the small rod is no longer exposed to the variable tension resulting from high hydrodynamics, thus greatly reducing the risk of breakage and unintentional release.

3/ A robust mooring line: The main elements of the MASTODON-2D mooring have been retained. The design of the 2D-OS is shown in **Figure 3**. The mooring line consists of a plastic *Nokalon* float (model 511, yellow) with a net buoyancy of 7.5kg. The main rope is a *Dyneema®* SK78 with a diameter of 4 mm and a breaking strength of 1400 kg. Its total length depends on the depth of sites, ranging between 40 and 80 m depth. A loop is made on the rope so that the unrolled length is equal to the water depth minus 10-15 m. This loop is then gripped by a *Dyneema®* link that passes through the flange and is attached to the small rod of the acoustic release system or to the mechanical release unit as described above. The total length of the rope is calculated so that at least half the depth of the site remains available in the drum because if there is current at the recovery, the buoy can sink because of the drag on the buoy. When the release system is triggered, the acoustic release system releases the *Dyneema®* link, allowing the submerged float to rise to the surface and remain attached to the frame. A loop is made in the rope at the desired depth and the probes are fixed with Colson TM. Surprisingly, users indicated that it was sometimes difficult to recover the MASTODON-2D because the lines had been cut near the surface and then probably thrown back into the water (Pairaud, pers com). To overcome this problem, a second safety float is positioned just above the structure. This should allow the system to be recovered even if the mooring line is partially cut.

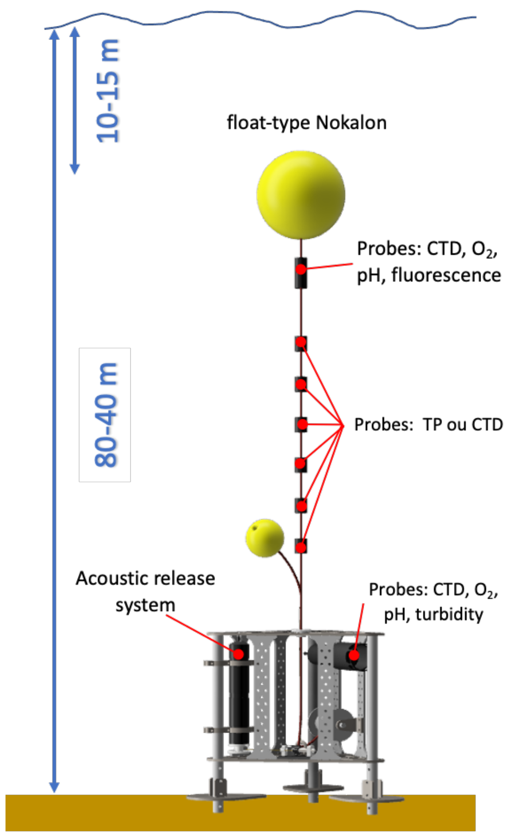

Figure 3. Design of the 2D Observatory Station

4/ A diversity of probes on the 2D Observatory Station

The initial objective of the MASTODON systems was to deploy numerous moorings at a very low cost (<2k€; Lazure et al 2019) to monitoring the bottom temperature over time at high spatial and temporal resolution. Therefore, the original design of MASTODON only included temperature probes (Lazure et al 2015). The 2D upgrade consisted mainly of adding loggers equipped with temperature and pressure sensors at different depths on a mooring line (Lazure et al 2019).

Our work in the WGMP since 2010 has shown the existence of seasonal O_2 dynamics with a well-oxygenated water column in winter and a bottom water O_2 depletion to 45% in autumn (Dubosq et al 2022). Several hypotheses have been proposed (e.g. seasonal stratification, advection of deoxygenated water), but the positive correlation between pH and O_2 would suggest that aerobic respiration plays a key role in this deoxygenation as observed in other RiOMars systems (e.g Cai et al 2012, Mucci et al 2011). At this stage, identify the processes controlling bottom water deoxygenation requires continuous monitoring of key hydrological and biogeochemical characteristics of the water column. In addition to temperature, it is essential to monitor also at least salinity, O_2, turbidity, and Chl-*a*. Therefore, the 2D Observation Station and the mooring line are equipped with appropriate probes (**Figure 3**):

(i) In the frame on the seafloor:

Parameters: temperature, salinity, pressure, O_2, pH, turbidity

Probes:

- STPS or Wisens 2 CTDS (NKE instruments) for temperature, salinity, pressure
- SDOT or Wisens 2 DO (NKE instruments) or MiniDOT® logger (PME) for temperature, O2
- STBD ou Wisens 2 TBD (NKE instruments) for temperature, pressure, turbidity

Or

- Multiparameter Wimo plus probe (NKE instruments) for temperature, salinity, O_2, pressure, pH and turbidity *(ii) On the mooring line:*

TP and/or DST-CTD probes are enclosed in small protective grating (type oyster bag), which are mounted at different depths along the mooring line (e.g. each 5 or 10 m depth depending on the total depth of the station).

- Temperature and pressure loggers (IFREMER); see Lazure et al (2019) for details.
- DST CTD loggers (Star-Oddi) for conductivity, salinity, temperature and depth

(iii) Below the subsurface float:

Parameters: temperature, salinity, pressure, O_2, pH, Chl-a, turbidity

Probes: the probes are enclosed in small protective grating and fixed right below the subsurface float

- STPS or Wisens 2 CTDS (NKE instruments) for temperature, salinity, pressure
- SDOT or Wisens 2 DO (NKE instruments) or MiniDOT® logger (PME) for temperature, O_2
- STBD or Wisens 2 TBD (NKE instruments) for temperature, pressure, turbidity
- Wisens 2 Chloro a (NKE instruments) for temperature, pressure, chlorophyll-*a*

4/ Deployment and recovery

Once all the loggers are started and the acoustic release unit is initialized, the deployment is initiated similarly to the procedure used for the MASTODON-2D (Lazure et al 2019). Briefly, it consists of throwing first the buoy into the sea with the mooring line to which the probes are attached, and then the frame. This operation requires to know precisely the depth since the buoy has to be at about 10 m below the surface. The frame is not accompanied in its descent by the ship's winch. Its free-falling speed will be estimated on next week. It is important to note that Thelma Biotel, the supplier of the TBR 800, has initiated a major upgrade of the TBR units in October 2023. They have found that the contact for the positive battery pole can be damaged (or dislodged) when the unit is dropped on the ground/seafloor (or otherwise struck). This can cause the battery to disconnect, and in severe cases cause the battery to leak. The acoustic release system will thus no longer work and recovery of the equipment will be impossible. Although all TBR units have benefited from the replacement of the battery compartment with a new rugged one design that have been successfully tested, we decided to try a new deployment option. This consists of a more delicate deployment using the vessel's winch with an additional *Dyneema*® rope of 10 + 5 m in length fixed on the submerged float. Once the frame is lowered to the seabed, the additional rope will be left at sea. This configuration will be tested in the coming months. A series of 3 deployments is scheduled to test the deployment/recovery procedure with the acoustic release system in the Arcachon Bay from March 2024. In addition, a Master student will work with the system between May and June 2024. Our objective is to have the 2D Observatory System ready to be deployed in the WGMP in October 2024 during the cruise RIOMAR-VOG2024 on board the R/V Côte de la Manche.

Acknowledgments: We received technical advice and valuable feedback on the MASTODON systems from Pascal Lazure, Ivane Pairaud and Hugo Sellet (LOPS, IFREMER, Brest) and an assistance with the 3D drawings from Bastien Lamarque (EPOC, Université de Bordeaux). Special thanks to Jean-Christophe Pellegrin (UF STE, Université de Bordeaux) for the 3D printing of several parts of the 2D-OS and Franck Delalee (UMS, OASU) for a few machining.

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<u>Publications, thesis, master internship (associated to the deliverable):</u>

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