Joint European Research Infrastructure network for Coastal Observatory – Novel European eXpertise for coastal observaTories - **JERICO-NEXT**	
Deliverable title	Report on the Mastodon2D mooring system
Work Package Title	Innovations in Technology and Methodology
Deliverable number	DL.3.5
Description	Low-cost mooring to explore internal waves in the coastal ocean
Lead beneficiary	IFREMER
Lead Authors	P. Lazure, I. Pairaud, S. Leizour, I. Puillat
Contributors	
Submitted by	P. Lazure
Revision number	V1.1
Revision Date	08/08/19
Security	Public

The JERICO-NEXT project is funded by the European Commission's
H2020 Framework Programme under grant agreement No. 654410
Project coordinator: Ifremer, France.

History			
Revision	**Date**	**Modification**	**Author**
1	19/07/2019	gathering of inputs from co-authors	P. Lazure
1.1	08/08/19	Update after WP lead review	P. Lazure

Approvals				
	Name	**Organisation**	**Date**	**Visa**
Coordinator	Patrick Farcy	Ifremer	09/08/19	PF
WP Leaders	George Petihakis Laurent Delauney	HCMR fremer	08/08/19	

Table of contents

1. Executive Summary

Temperature distributions on continental shelves (depth < 150m) are often complex because the many physical processes induce very high spatial (both horizontal and vertical) and temporal variability. Temporal variability extends from a few tens of minutes for solitons (internal wave), a few hours for internal tide and inertial waves to a few days for upwelling or sub mesoscale dynamics.

In the 1980s, satellites provided access to knowledge of surface temperatures. On the other hand, the internal temperature structure still requires in-situ measurements, which leads to the deployment of moorings at sea. These operations are often expensive and risky because the coastal zone is generally subject to intense activities such as fishing and sea conditions can be very harsh.

Profiling systems exist, as an example, they are either derived from the drifter ARVOR C or at the fixed location such as the Wirewalker™. However, these systems are expensive, which limits the number of deployments and does not allow time series to be obtained in a fixed immersion with a fine time resolution (for a depth of 150m, a vertical profiler speed of 1m/s only allows the bottom temperature to be measured every 5 minutes).

Our development avoids these disadvantages by proposing the development of a system equivalent to thermistor chains at a much lower cost. The counterpart is that the fine description of the vertical profile depends directly on the number of probes on the line and will never be as fine as that provided by a profiler. On the other hand, it allows to obtain at a low cost, time series at the fixed station and at the selected immersions.

The Mastodon2D mooring (t-z, description of temperature variations over time on the water column) is an extension of the Mastodon mooring (Lazure et al., 2015) which allows to measure the temperature evolution near the sea bottom. The innovation does not lie in the measured parameter (thermistor chains have existed for decades) but in the possibility to deploy numerous moorings thanks to their low cost (<2000 €, at least 10 times less than conventional thermistor systems) and providing good quality data at high spatial resolution.

The system is described in detail and the first deployment with scientific benefits is briefly presented to illustrate the effectiveness of such development. Future developments and industrial challenges are then discussed.

2. Introduction

The internal waves consist of oscillations of the isotherms on the vertical. Their presence in the oceans has been known for decades, but the contributions of satellite imagery, both optical and mainly by radar (SAR), have shown that waves are present in the global ocean, both in the deep ocean and in coastal areas (Appel, 2000). They cover a wide range of frequencies from a few minutes to the period of the semi-diurnal or diurnal tides. However, another class of internal waves, the elevation waves near the bottom, are very difficult to see from space (Klymak and Moum, 2003; Moum and Smyth, 2006) and their detection can only come from in situ moorings.

If satellites provide a snapshot at a given date, they do not allow the propagation characteristics and amplitude to be easily deduced. Their observation is not simple because the detection of these oscillations requires in situ measurements at different depths. The conventional way of measuring is to use thermistor chains whose number of sensors can vary from a few dozen (e.g. Zhang and Alford, 2015) to more than a hundred (Cyr et al., 2016).

Upwellings and downwellings are vertical movements of water masses near the coasts that are generated by the wind and preferably by the winds along the coasts. While upwellings can be easily detected by satellite imagery because upwelling results in cold water on the surface, downwellings are generally not detectable by satellites. On the other hand, the movements of isotherms in the water column are particularly interesting to study because they trace water masses and their impact on the geochemistry of coastal zones. As with internal waves, these isothermal movements can only be measured by in situ moorings and the deployment time scales are similar (~15 days minimum).

Depending on the applications targeted, temperature sensors have different characteristics regarding the accuracy of the measurement and the time constant (thermal inertia of the system) that determines the maximum measurement frequency. Temperature probes with very good accuracy and the ability to perform high frequency measurements (van Haren, 2018) make it possible to detect internal wave surges and infer the characteristics of the induced mixing. However, high frequency requires a perfect synchronization of the clocks, which leads to moorings that can become very expensive. On the other hand, many low-cost sensors are now available, their measurement uncertainty is in the order of 0.1°C and the characteristic times are in the order of one minute or more (Whiteman et al., 2000). This precision, which may seem low, is however commonly adopted in coastal areas where the temperature differences between the surface and the bottom can exceed 10°C in summer.

The objectives of Mastodon2D moorings are to provide an in situ description of internal waves and up/downwelling in areas where they are visible by satellite imagery but whose characteristics have never been measured. The targeted areas are the continental shelf (depth < 150m) where observations are generally risky due to the vandalism and harsh sea state. In order to be able to deploy multiple exploratory moorings without operational constraints (real time) at different sites and without using conventional oceanographic means, low-cost moorings have been developed. These moorings aim at describing the evolution of temperatures in the water column during at least 15 days (a spring-neap tidal cycle) with a variable vertical resolution that can be adapted according to the vertical location of the thermocline.

The first paragraph of this report describes the specifications and justifies the choices made. The second is dedicated to the description of the mooring. The third concerns metrology. Some examples of recent deployments with scientific issues are provided in paragraph 4. Possible technical improvements and industrialization issue are presented before the conclusion.

3. Main report

3. 1 Specifications

The specifications and technical solutions selected were guided by 5 choices:

- **A low-cost, lightweight mooring**

The main constraint that applied during development was to design a complete low-cost mooring for both the sensors, their electronics and the mooring itself. Moreover, the implementation for deployment and recovery has also been designed so that they can be operated from a small vessel, not necessarily oceanographic or equipped with significant lifting equipment. This required a lightweight mooring. We used the original Mastodon mooring that was originally intended to acquire sea floor temperature data on the continental shelf.

- A subsurface float

To be able to make measurements in the water column at the fixed point, it is essential to use a buoy either on the surface or on the subsurface. The choice was made very quickly for a subsurface buoy for two reasons: on the one hand to avoid vandalism and on the other hand to limit the impact that storms have on moorings whose buoys are on the surface. This would not have been compatible with the constraint of a light mooring and would have required the use of a robust and signaled buoy, which is not compatible with the constraints of low cost and implementation from a light craft. In its nominal configuration, the buoy is located 10m below the surface; this allows most ships to pass over it. This depth can easily be modified.

-A reliable and inexpensive release system

The drawback of a subsurface buoy is the need to use a release system that allows the buoy to surface for recovery. The acoustic releases used conventionally did not allow the constraints of low cost to be respected. Although new low cost acoustic release systems are beginning to appear (Crook et al., 2018), we have used the burn wire system of the original system. The major disadvantage of this choice is that it requires the recovery date to be scheduled at the time of deployment and that weather conditions are generally not predictable over several weeks.

-A pressure sensor and oil conditioning

The temperature sensor and acquisition system are essentially the same as for the original version of the Mastodon mooring. The measurement uncertainty is 0.1°C. The measurement of the probe depth required the inclusion of a low-cost pressure sensor on the electronic board. Conditioning in an enclosure at atmospheric pressure would have required the 2 sensors (T and P) to be relocated, which can quickly become costly because it raises waterproofing problems that could limit the maximum depth of deployment.

As a result, the presence of both sensors on the electronic board requires oil conditioning with the need for the time constant to be as low as possible. Nevertheless, since the T/P sensors are independent of each other (i.e. without synchronization) the very high frequency is not possible because of the drift of the clocks of each probe. The oil conditioning of the pressure sensor also places a strain on the type of equipment used. It is necessary to ensure that the sensor is in iso pressure with the external environment and that the conditioning does not disturb the pressure measurement.

-Simple and secure software

The low-cost, oil-packed T/P probes communicate with a computer through a Bluetooth wireless interface. A magnet close to the probe allows dialogue with the PC equipped with a dongle. This allows remote programming without cables. The software must be simple to avoid the risk of errors and the number of features limited to the strict minimum. On the other hand, a led at the top of the card allows to have a quick check of the programming status (on or off).

3.2 Description of the Mastodon2D

- Original Mastodon mooring

The first developments of Mastodon mooring (MApping of Seabed Temperature and Observation of DOwNwelling) were aimed at mapping bottom temperatures on the continental shelf and in particular the effects of downwellings, which result in a sudden increase in bottom temperatures in a few days (or even in hours). The system has been described in detail (Lazure et al., 2015), we will only mention the main elements here.

The schematic of the Mastodon system is in Figure 1, and its core is a near-bottom temperature data logger with ballast and a release device. The release device is innovative and based on «a burn wire » (electrolytic erosion of a copper wire loop under low voltage). To date the release is software-controlled and defined before deployment. Given the uncertainty in marine weather forecasts and ship availability, the temperature probe and its float will remain fastened to the ballast after the release date, to allow recover a few days later, if necessary.

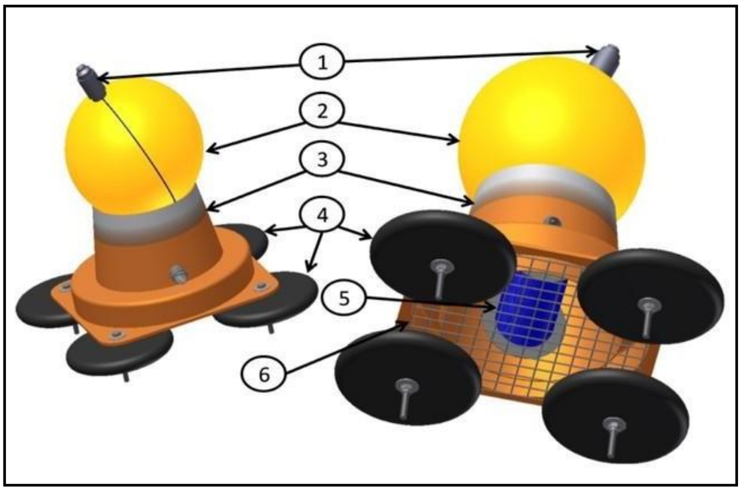

Figure 1: *Scheme of MASTODON* (Lazure et al., 2015).
1-electronics, 2- float, 3- traffic cone frame, 4- ballasts, 5- rope spool, 6- wire grate.

The electronic card (Figure 2) has been especially developed for this instrument. The temperature sensor is included in the microcontroller. The electronic board, the batteries (for the probe and burn wire combustion) and one end of the burn wire are packaged in a tube filled with oil (Marcol 82). This pipe has the electronics at the upper end, it passes through the buoy and includes 3 AAA batteries. At its lower end the burn wire which shows a loop of copper wire that is attached to the frame. During the release, the combustion of the copper wire releases the buoy which rises to the surface by unrolling a 3mm rope attached to the frame. The recovery of the assembly (buoy with electronics and frame with ballast) can thus be carried out from a ship. The system is lightweight (~25kg in the air) and can be lifted from a small boat, even by hand (with a good pair of gloves). More than 50 deployments have been made since 2015 and the system has proven to be very reliable.

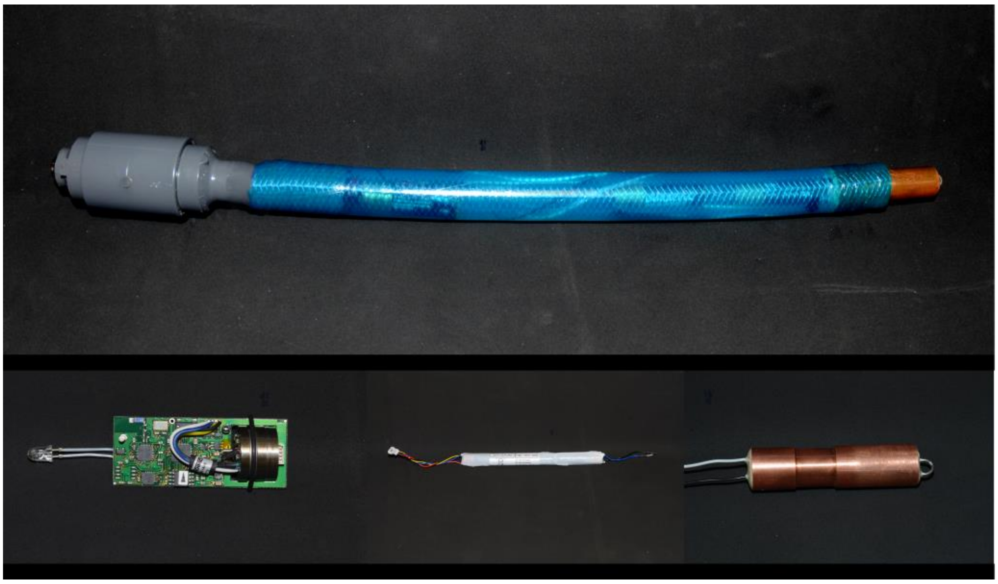

Figure 2: *Electronics of the original Mastodon system.*
Top: *plastic tube passing through the buoy. At its left end, a container enclosing the electronic card.*
Bottom left: *electronic card with a diode allowing to know the programming status of the system.*
Bottom middle: *energy pack composed of 3 AAA batteries.*
Bottom right: *"burn wire" type release system.*

- Mastodon2D mooring

The main elements of the Mastodon mooring have been preserved. The design of the Mastodon2D is shown in Figure 3.

The positive buoyancy for mooring floatation is provided by a 280-mm-diameter plastic fishing net float (Nokalon 511), with a central hole of 24 mm. This float has a net buoyancy of 7.5 kg. The main string is made of 16 strand continuous polyester with a core of aramid parallel, its section is 3mm and its resistance almost 300kg. At the desired immersions for the probes, a loop is made in the rope and each probe is fixed with a Colson™.

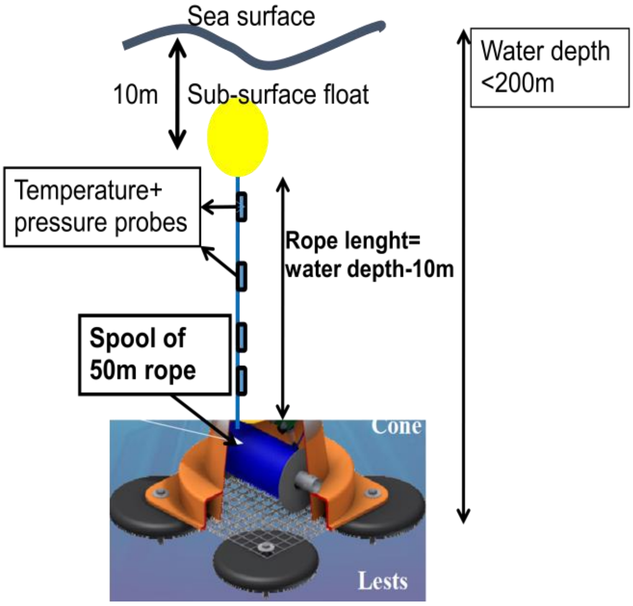

***Figure 3:** Conceptual design of Mastodon2D*

The main modification from the original design was to add a stainless steel flange on the upper end of the traffic cone (Figure 4, left). Under the flange is fixed the burn wire and the pipe with the electronics (Figure 4, right). A loop is made on the rope so that the length unwound is equal to the water depth minus 10 m. This loop is then grasped by a Dyneema link that passes through the flange and is attached to the burn wire. The total length of the main rope is calculated so that there is at least 50 m left in the spool of rope. When the release date is reached, the burn wire releases the Dyneema link and thus allows the subsurface buoy to rise to the surface and remain attached to the frame.

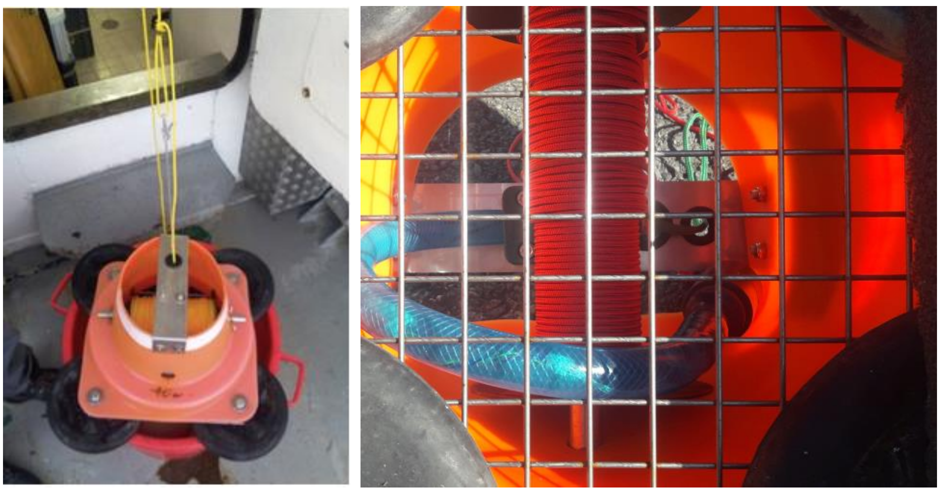

***Figure 4: Left:** top view of the frame. **Right:** bottom view of the frame.*
The plastic pipe and the fixing of the burn wire under the stainless steel bar are visible.

- Mastodon2D temperature/pressure probes

A very efficient and inexpensive (~15€) pressure sensor (MS583730BA01-50) was added to the original card.

To reduce the response time of the temperature sensors, the electronic board and its battery (a battery of type AAA) are packaged in heat-sealable plastic bags filled with Argol 82 oil (Fig. 5, left). The bags are then protected by a plastic mesh used in gardening. Each probe has a size of about 14cm x 4cm x 2cm and a virtually zero weight in water.

Figure 5: Left: *electronic card packaged in heat-sealable bags.*
Right: *T/P probes with protective grating.*

The internal memory is 4Mo. It allows to make 3 days of recording with a time step of 1 second by recording the temperature, pressure and voltage of the battery. This provides autonomy of 180 days with a time step of 1 minute. Battery consumption has been optimized and a single AAA battery allows continuous recordings of more than one year with a time step of 1 minute.

- Deployment and recovery

To program data sampling, start data collection or retrieve data samples, a magnet is approached from each probe and triggers a detection switch. Once detected, the LED indicator starts blinking and the high-frequency data link is powered on. Equipped with a high-frequency USB dongle, a personal computer runs the human-machine interface that connects it to the data-logging system. The only parameter for programming the probe is the time step and for the frame the date and time of recovery.

The Deployment of the Mastodon2D is almost as simple as the deployment the original mooring.
It consists of throwing first the buoy into the sea and unrolling the rope to which the probes are attached. The frame is deployed last. This operation requires precise knowledge of the depth so that the buoy is about 10m below the surface. The free falling speed is about 1m/s, so it will take 90 seconds for the frame to land at a depth of 100m. If the current is about 1 knot, the mooring can be shifted by about 50m. This operation can be delicate in regions where the bottom slope is steep (example of the Mediterranean Sea). Mooring at too shallow a depth can lead to the buoy being too close to the surface (or even on the surface). A mooring that is too deep can make the rope too short and can cause difficulties for recovery, because if there is current, the buoy can sink because of the drag on the buoy.

Recovery takes place in several stages. The first step is to locate the buoy on the surface. The first tests with white buoys made this task more difficult because of confusion with seabirds or sea foam. The buoys are now painted with a yellow fluorescent paint. Reflective strips have been added to make detection easier. Once the buoy is located, it must be grabbed with a pike pole and brought back on board. This is the most delicate step because the tension on the rope can be high if the ship drifts. In this case, the frame with the ballast cannot slide on the bottom due to protruding screws and the tension on the string is applied laterally. The risk of rope breakage is maximum at this moment even if the first meter (close to the coil) is protected from rubbing by a sleeve. It is necessary to return slowly to the mooring so that it returns to the vertical of the ship. The rope is passed through a winch and the lifting can begin. Each time a probe comes out of the water it is necessary to detach it to continue the maneuver (Fig. 6, left). The operation continues until the frame is raised (Fig. 6, right).

Figure 6: Left: *temperature sensor in a Mastodon2D mooring line.*
Right: *end of the recovery, the frame appears at the surface.*

3.3 Metrology

Calibration of temperature

- Stability

The temperature probes were calibrated in a thermostatic bath with 5 steps from 5°C to 25°C every 5°C. The recording time step was 15 sec and for each step the temperature was stabilized for one hour. The standard deviation of the measurements over 30 minutes is shown in Figure 7. It varies between 0.015°C and 0.021°C. We can therefore consider that the stability of the measurement is correct.

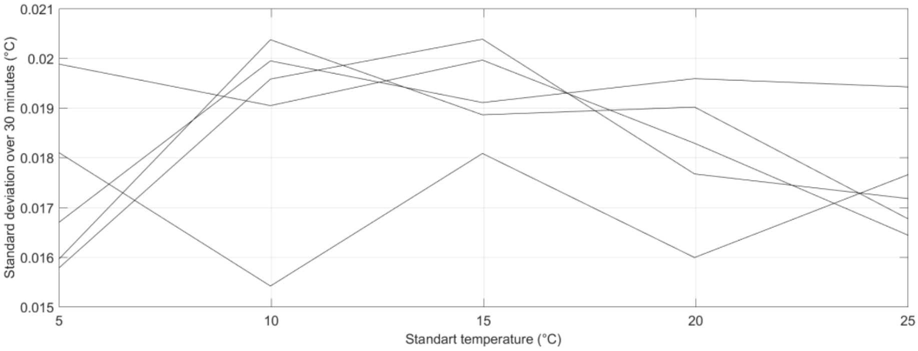

Figure 7: *temperature standard deviation measured by Mastodon2D probes during 30 minutes*

- Bias

The average bias is for each probe varies from -0.08°C to -0.12°C (Figure 8). We note that the bias increases with temperature; it varies from -0.06°C for a temperature of 5°C to -0.15°C for a temperature of 25°C. Using an average bias of -0.10°C, the measurement uncertainty becomes about 0.1°C, which is in accordance with the initial specifications.

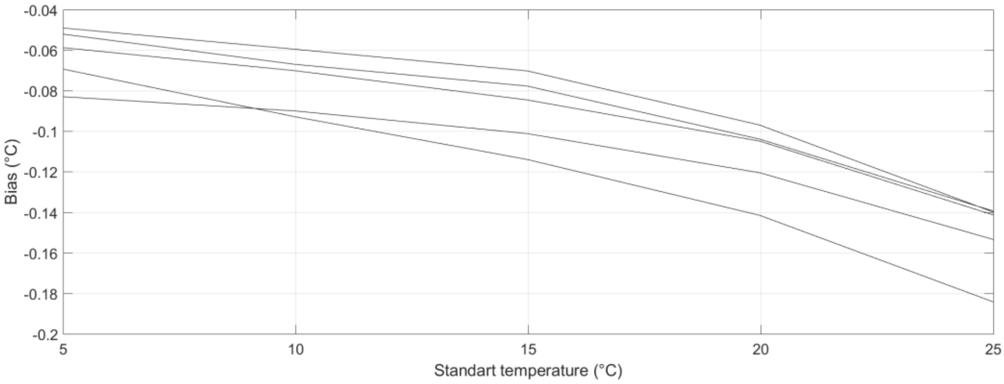

Figure 8: *Measured bias from 5°C to 25°C every 5°C*

- Time constant

The thermal inertia caused by the electronic board and oil conditioning do not allow an instantaneous measurement of the temperature. The evaluation of the time constant (equal to the time required for the measurement to reach 63% of the temperature variation) was calculated. Figure 9 shows the adjustment times of 4 probes moved from a bath at temperature of 23.5°C to 26.5°C. The two black lines correspond to the theoretical curves for adjustment times of 20 sec (solid line) and 40 sec (dashed line). It appears that for this batch of probes, the adjustment time is within these limits. Multiple tests have been performed and the conclusion is that the majority of probes behave in the same way. This imposes a maximum limit on the sampling frequency which is set at 1 measurement/minute.

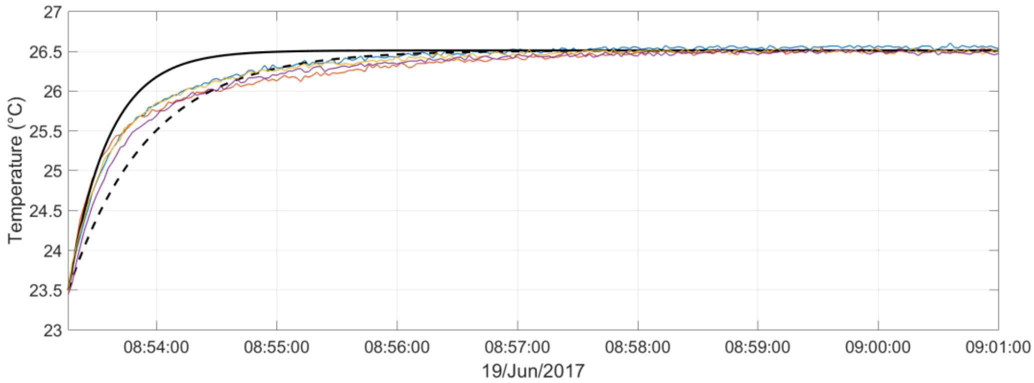

Figure 9: *Evaluation of constant time for 4 probes. The theoretical curves corresponding to time constants of 20 and 40 sec are in black.*

Pressure Sensor

The pressure sensor has been added to the temperature measurement to know the depth of the probe knowing that the mooring can be tilted by the current. The precision required was about 10 cm. It turns out that it is better and may allow other uses as we will see in the prospects for improvement. In the summer of 2017, the Etoile campaign, carried out as part of JRAP 4, provided an opportunity to evaluate the accuracy of the pressure sensor. A Mastodon2D mooring was positioned near an ADCP current meter in about 60m of water off the coast of Landes (FR) (44°00' N, 1°31' W). The comparison between the pressure recordings at 1m from the bottom by the ADCP (RDI 300kHz) and the Mastodon measurements (Figure 10) shows deviations that are very small and generally in the order of cm. The period (21-23 July) when the pressure signal is noisiest corresponds to a small storm (swell > 2m) when the mooring had to bend slightly under the effect of the waves.

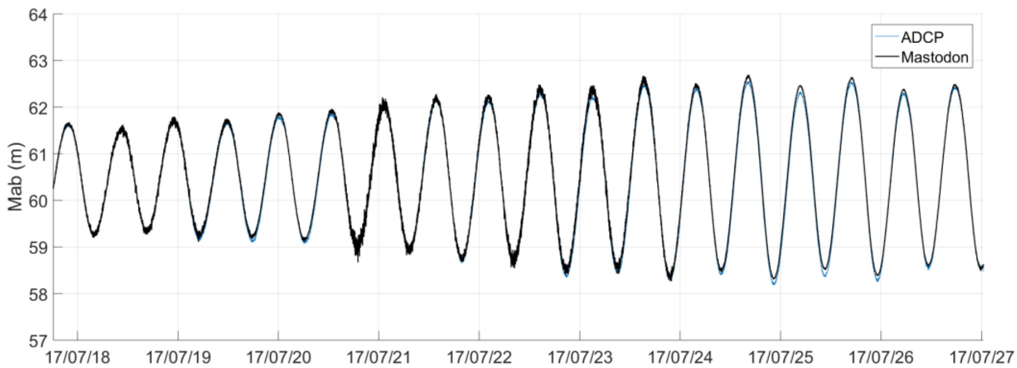

Figure 10: *Comparison between bottom pressure recorded by the ADCP (blue line) and Mastodon2D mooring (black line).*

3.4 Scientific applications

- Internal wave assessment in the south-eastern corner of the Bay of Biscay

The Etoile campaign took place in the south-eastern corner of the Bay of Biscay from 9/07 to 8/08/2017. One of the objectives was to characterize the internal waves on the continental shelf.
The Mastodon2D mooring were deployed according to 3 transects (Figure 11). Each transect had 3 moorings at depths of 60m, 100m and 150m. All moorings at 100m depth were lost due to intensive fishing activity around this isobath. Six moorings were recovered. Each mooring had temperature and pressure sensors every 10m

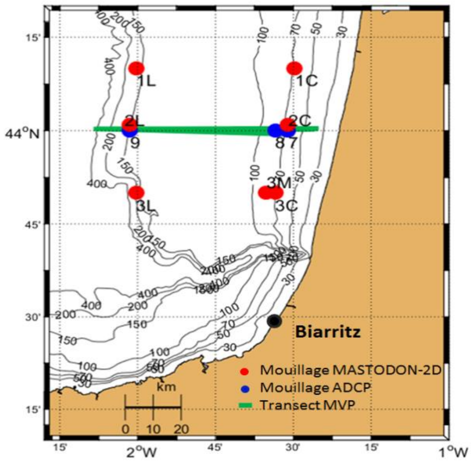

Figure 11: *Location of the Mastodon2D moorings during the Etoile campaign*

Figure 12 illustrates the evolution of isotherms at station 2C over a few days. The Mastodon2D at this location included 6 T/P probes. The internal tide can be observed, illustrated by oscillations at semi-diurnal period (about 12.5 hours), which is the dominant period of the tide in the Bay of Biscay. The amplitude of the internal tide is about 10m. This low-frequency oscillation is overlaid by oscillations with a period of about 20 minutes. These oscillations propagate in packets and are called internal solitary waves train or solitons. Their amplitude can reach 20m and they occur at the front of the internal tide.

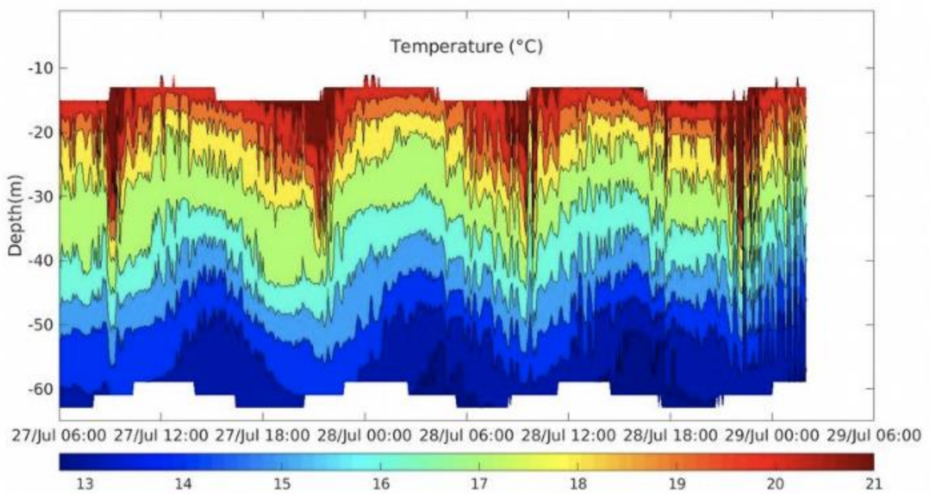

Figure 12: *Temporal evolution of temperatures between subsurface (~12m) and bottom measured by the Mastodon2D mooring at station 2C.*

This campaign was the first to highlight the existence of solitons in the Bay of Biscay on the continental shelf. Hydrology measurements from Mastodon2D moorings combined with current measurements have provided us with a comprehensive dataset to characterize these internal waves in the coastal zone and their fate near the coast. A scientific publication will be submitted before the end of the year.

- Study of coastal upwelling in the Mediterranean Sea

The Upcast campaign made it possible to deploy 4 Mastodon2D moorings for one month at the end of summer 2017. These moorings were located between 120m and 200m deep (Figure 13) between Marseilles and Toulon. Each mooring had 10 T/P probes.

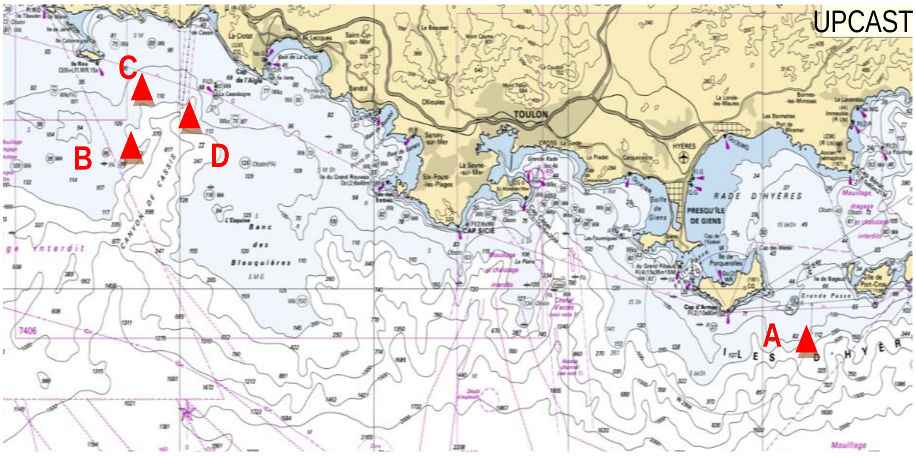

Figure 13: *location of the 4 Mastodon2D deployed during Upcast campaign*

The temporal evolution of temperatures at mooring B at different depths is shown in Figure 14. The sub-surface probe (purple curve) shows a very high temporal variability and reveals the birth of an upwelling on 31/08. The temperature decreases by 10°C in 2 days and remains stable at values of about 15°C until the end of the recordings.

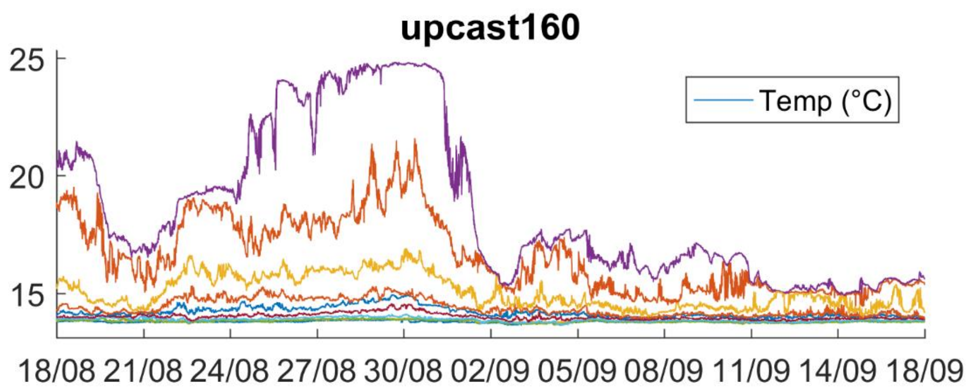

Figure14: *temporal temperature evolution of the 10 T/P probes from 10m below the surface to 100m (decreasing temperature downward).*

Mastodon2D moorings have been part of a set of physical parameter measurements (ADCP, glider, AUV) that are currently being interpreted and will contribute to a better understanding of the complex dynamics of upwelling in the vicinity of canyons. These data will also be used to validate a 3D hydrodynamic model (Pairaud et al, 2017).

3.5 Areas for improvement

Several developments could improve the system:

=> The subsurface buoy does not allow to measure the first 10 meters. As a general rule, the surface layer is well mixed but in calm weather, a secondary thermocline may develop that the actual system does not allow to measure. Considering the zero weight of the probes in the water, the surface layer could be sampled by one or more probes that would be attached to a line attached to the main float and stretched to the surface by a float of a few cl of buoyancy. It is important that the surface float is small and not very visible and especially that this secondary line has little breaking strength (qq kg) which would allow it to break in case of vandalism and would not affect the main mooring.

=> The packaging of electronic cards is a time consuming process and thus increases the real cost of T/P probes. It would be necessary to find a way to automate this task without compromising the quality of the pressure measurement or the temperature response time. Reflection is ongoing.

=> A simple modification of the firmware (program embedded in the probe was performed so that the maximum acquisition frequency goes from 1sec (currently) to 10hz to test the ability of the pressure sensor to measure waves. An experiment was carried out for 20 minutes in the port of Le Conquet (FR) at a depth of 2 m with 4 Mastodon2D and a probe considered as a reference for wave measurement by bottom pressure sensor (OSSI). Figure 15 shows the comparison between the 4 sensors of the Mastodon2D and the OSSI (black curve) probe. The agreement between all the measures is encouraging and allows the use of this sensor for other applications to be considered. However, for use in this configuration, the firmware must be rewritten to add the burst function and manage the energy.

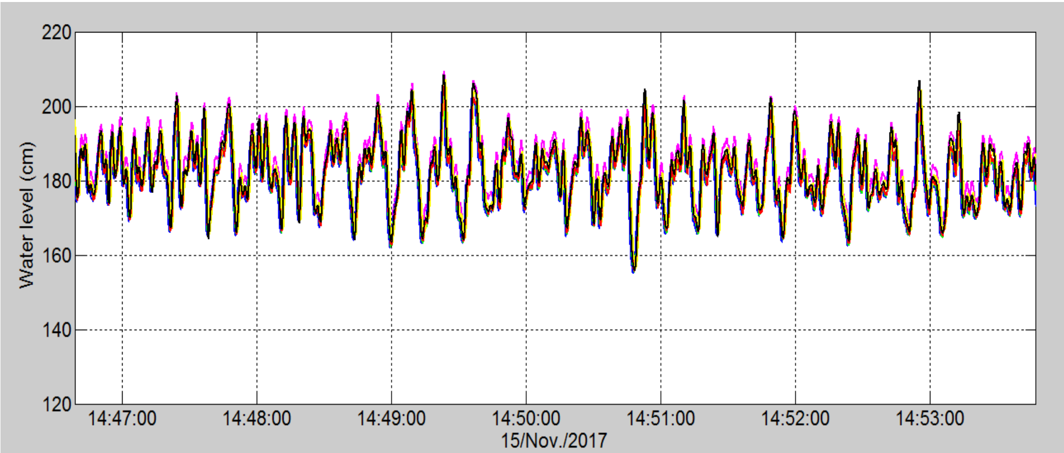

Figure 15. Comparison between bottom pressure measured by Mastodon2D pressure sensor and OSSI (black curve) at 10 Hz.

3.6 Industrial opportunities

A survey of environmental services (government and private) on the interest in measuring background temperature showed that outside the scientific world, this interest was not strong. However, there seems to be a market for increasing the parameters measured particularly oxygen and/or turbidity. Therefore, a private company is currently taking the original concept of the first generation Mastodon and adding an O2 and turbidity sensor. The original materials (traffic cone) have been abandoned in favor of stainless steel frames, which are easier to build and maintain. The first trials are underway and marketing is expected to begin in 2020.

Concerning Mastodon2D, there are no current plans for industrialization, but the interest of several research organizations in France (SHOM, IRD, CNRS) and Canada (DFO) could allow a pooling of resources to improve the manufacture of systems and thus further reduce their costs.

4. Outreach, dissemination and communication activities

Please describe all outreach and communication activities carried out to promote the deliverable results and products to stakeholder user groups. Specify individual activities and targeted groups as appropriate.

Reference who quote Mastodon/Mastodon2D

Journals

Lazure Pascal, Le Cann Bernard, Bezaud Marion (2018). **Large diurnal bottom temperature oscillations around the Saint Pierre and Miquelon archipelago**. *Scientific Reports*, 8(1), 13882 (12p.). Publisher's official version : https://doi.org/10.1038/s41598-018-31857-w ,

Lazure Pascal, Le Berre David, Gautier Laurent (2015). **Mastodon Mooring System To Measure Seabed Temperature Data Logger With Ballast, Release Device at European Continental Shelf** . *Sea Technology* , 56(10), 19-21 .

Symposium

Gauthier Victor, Puillat Ingrid, Lazure Pascal, Baquet Emeric (2018). **High frequency hydrodynamics in the South-East of the Biscay Bay from in situ measurements** . ISOBAY 16 - XVIth International Symposium of Oceanography of the Bay of Biscay. 5-7 June 2018, Anglet, France .

Pairaud Ivane, Garnier Valerie, Le Berre David, Ravel Christophe, Leizour Stephane, Lazure Pascal, Garreau Pierre (2017). **Mastodon-2D. Deployment in Mediterranean Sea During Upcast field Experiment** . MonGOOS Workshop "Mediterranean Sea Observing System". November 14 2017, Athens, Greece . https://archimer.ifremer.fr/doc/00412/52310/

Puillat Ingrid, Lazure Pascal, Artigas Luis-Felipe, Delarbre Jean, Louchard Arnaud, Rubio Anna, Basurko Oihiane, Caballero Anna, Davila Xabier, Gauthier Victor, Baquet Emeric (2018). **How does the JERICO Research Infrastructure support marine science in the Bay of Biscay?** ISOBAY 16 - XVIth International Symposium of Oceanography of the Bay of Biscay. 5-7 June 2018, Anglet, France .

Puillat Ingrid, Lazure Pascal, Artigas Luis-Felipe, Delarbre Jean, Louchard Arnaud, Rubio Anna, Basurko Oihiane, Caballero Anna, Davila Xabier, Gauthier Victor, Baquet Emeric (2018). **How does the JERICO Research Infrastructure support marine science in the Bay of Biscay?** ISOBAY 16 - XVIth International Symposium of Oceanography of the Bay of Biscay. 5-7 June 2018, Anglet, France .

5. Conclusions

Mastodon2D moorings offer the opportunity to deploy the equivalent of thermistor chains on the continental shelf at a low cost, which increases the number of moorings deployed and thus increases the spatial resolution of the observations. During the years 2017-2019, approximately 50 Mastodon2D moorings and 250 T/P probes were built. The data return rate is very good and qualifies the system. The advantages of these moorings are numerous:

- The flexibility and speed of assembly and positioning of the probes, which can be adapted to the objectives sought and to local hydrology.

- Lightweight that allows deployment and recovery from small boats.

- Robustness and reliability even in harsh sea conditions

- Quality data that allows its use in scientific research

6. Annexes and references

Apel (2000): Nonlinear Solitary Internal Waves by J. R. Apel and D. M. Farmer, Global Ocean Associates (GOA) Report 2000-2
September 2000, with additional material taken from [Apel, 1987,Apel,2000 and Apel and Worcester, 2000].
http://www.sarusersmanual.com/ManualPDF/NOAASARManual_CH07_pg189-206.pdf

Crook, D.A., Adair, B.J., Hetherington, L.J., 2018. Low-cost device for retrieval of moorings deployed with underwater remote release systems. Mar. Freshwater Res. 69, 473–476. https://doi.org/10.1071/MF17189

Cyr, F., van Haren, H., Mienis, F., Duineveld, G., Bourgault, D., 2016. On the influence of cold-water coral mound size on flow hydrodynamics, and vice versa. GEOPHYSICAL RESEARCH LETTERS 43, 775–783. https://doi.org/10.1002/2015GL067038

Klymak, J., Moum, J., 2003. Internal solitary waves of elevation advancing on a shoaling shelf. Geophysical Research Letters 30, 20,2045. https://doi.org/10.1029/2003GL017706

van Haren, H., 2018. Philosophy and Application of High-Resolution Temperature Sensors for Stratified Waters. Sensors 18, 3184. https://doi.org/10.3390/s18103184

Whiteman, C.D., Hubbe, J.M., Shaw, W.J., 2000. Evaluation of an inexpensive temperature datalogger for meteorological applications. J. Atmos. Ocean. Technol. 17, 77–81. https://doi.org/10.1175/1520-0426(2000)017<0077:EOAITD>2.0.CO;2

Zhang, S., Alford, M.H., 2015. Instabilities in nonlinear internal waves on the Washington continental shelf. J. Geophys. Res.-Oceans 120, 5272–5283. https://doi.org/10.1002/2014JC010638