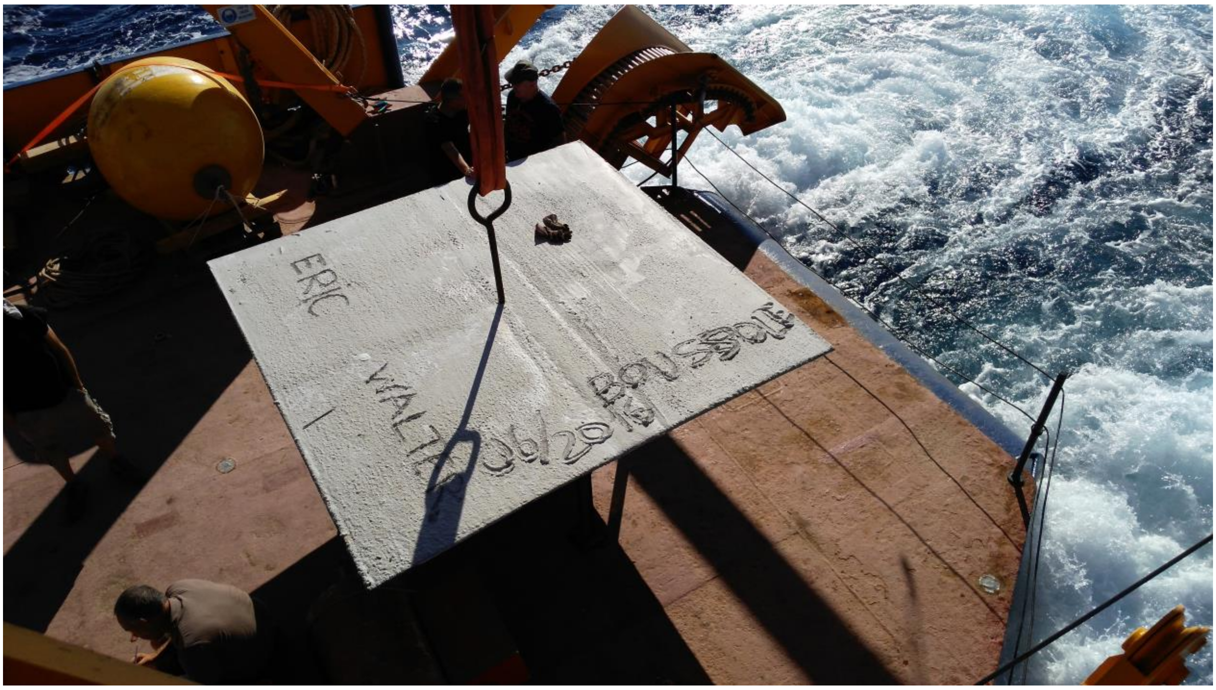
Full rotation of the BOUSSOLE buoy and mooring August 26-29, 2016



Picture of the dead weight on the deck of the "Castor 02" vessel, ready to be deployed at BOUSSOLE.

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BOUSSOLE Project

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Foreword

This report is part of the technical report series that is being established by the BOUSSOLE project.

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1 Cruise objectives, motivation for the buoy and mooring rotation

The objective of the cruise reported here was to recover the BOUSSOLE mooring line and buoy lower superstructure (see **App. 2** for a schematic view), and to reinstall a new mooring line and buoy lower superstructure. The buoy upper superstructure has been temporarily dismounted from the recovered lower superstructure and mounted onto the new lower superstructure.

The last similar operation took place on 12th to 14th June of 2013. This means the mooring line and the lower superstructure have stayed at sea about 38 months. No particular issues on the Kevlar cable and terminations were noticed after they were retrieved. The lower superstructure however suffered biofouling though the condition of the paint seemed still fine at visual inspection.

These operations are necessary as far as the longevity of the Kevlar mooring cable and of the lower superstructure (the main buoyancy) are still not totally know.

The excellent physical status of all mooring line elements confirms that a rotation every 3 years can be safely maintained in the future.

The Foselev Marine Company had a long closure in summertime right after the cable delivery and the first planned available day was August 23th. Mobilization of the CASTOR 02 eventually started on August 25th and the start of operations at sea was on August 26th (see the detailed cruise report below).

2 Preliminary organization before launching the deployment operations

2.1 Lower superstructure verification and preparation

After the mooring recovery of June 2013, the lower superstructure has been stored at the premises of the “Box Stockage Services” (BSS) company in Biot (formerly “Chantier Naval de Biot”, then “Global Refit”). The preparation of the lower superstructure took place there under the supervision of Jean François Desté. The preparation started in mid May 2016 and lasted about 1 month (the full calendar is reported in **App. 6**).

The scheduled interventions on the structure were: sandblast of the old paint, x-ray verification of the integrity of welds and of the thickness of metal sheets, painting, and installation of new anodes.

The x-ray checks were performed by the “IOA” company. Some defects were found on few weld joints of tubular structural elements. The necessary repairs were made before the structure be painted by BSS.

The painting was applied as successive layers of[1]: 2 layers of International protection, 1 layer of Primer Intergrad 269, 3 layers of Interzone 954, 2 layers of Intergard 263, 2 layers of Trilux 33. It is important to apply the last antifouling layer (Trilux 33) not earlier than 1 month before the deployment to guarantee its effectiveness. Protecting the structure from sun exposition also helps keeping the effectiveness of the antifouling.

Another crucial point is to have the anodes directly connected to the metal of the structure. Divers in charge of the deployment found that the paint was not removed over the contact zones and fixed this issue by removing the paint under the anodes before the deployment. They also painted the connection plate (i.e., the plate connecting the lower

[1] These references are those from the paint company “International”

superstructure to the mast) with white paint to ameliorate its visibility from surface after its deployment.

This structure was delivered to Foselev Marine on June 16th 2016.

When *en route* from La Seyne-sur-Mer to BOUSSOLE, plastic washers were fixed with epoxy glue ("Araldite" brand) on the buoy plate to avoid contact between stainless steel bolts and the buoy, which is made of simple steel (see **Pic. 5**).

2.2 Mooring line, in particular the Kevlar cable

A critical and preliminary step consists in determining the length of the Kevlar cable and its elongation under a strain of about 2.7 tons, which corresponds to the net buoyancy of the entire buoy and mooring line.

The principle is first to weigh a sample of cable of a precisely known length (minimum of 20 meters) with a high-precision scale, and then to adjust the length of the full mooring cable as a function of its total weight. This procedure proved to be robust, and is mandatory because the length meter used during the production of the cable is not accurate enough to give the requested precision of a few meters. The cable length must be computed so that it is at the desired value when under tension. The coefficient of elongation is estimated using a sample of the cable under production and the appropriate test bed for tension measurements. The cable manufacturer, Lapp Muller, performs all these operations and delivers a certificate describing these operations and the numerical values for the different weightings and elongation measurements (**App. 2**).

A problem during the production of the cable occurred on May 25th. The process had to be started again causing some delay in the delivery. A first delivery took place on June 17th, however the cable was missing its two terminations. It was then sent back to Lapp Muller in Grimaud for completing the operations before being definitively delivered to Foselev Marine on July 1st.

The acoustic release system was sent to Ixblue in Brest for general verification. O rings, anodes and lithium batteries were replaced by new ones. The battery of the acoustic command was replaced too.

2.3 Weather forecast

The recovery, and above all the deployment, of the BOUSSOLE mooring and buoy requires a perfectly calm weather and, ideally, no current. It is, therefore, mandatory not to start the operations with anticipated wind speeds above 10 knots. Forecasts below 5 knots for at least 2 days are the ideal situation. It is not recommended to start operations just after strong winds have blown, because the wind-generated surface currents usually take several days to attenuate.

Several weather forecast systems have been used in the preparation of the operations, in order to increase the confidence in the weather forecast as compared to what would be obtained using a unique source. They are:

The long-term forecast of the ECMWF (pressure fields), at:

http://www.ecmwf.int/products/forecasts/d/charts/medium/deterministic/msl_uv850_z500

Wind field forecasts of:

http://www.weatheronline.co.uk/cgi-bin/windkarten?03&LANG=en&WIND=g030

https://www.meteoblue.com/en/weather/forecast/week/villefranche-sur-mer_france_6425698
http://www.meteociel.com/modeles/gfs/resume/3h.htm
http://www.eurometeo.com/italian/ww3-lamma/jump_LAMMA-0
http://www.windfinder.com/forecasts/wind_italy_n12.htm
General marine weather forecast of Meteo France:
http://www.meteo-france.com/FR/mer/bulZone.jsp?LIEUID=LARG_LIGURE
Wave forecasts from Meteo France, Previmer and LaMMA
http://www.meteo-france.com/FR/mer/carteVagues.jsp?LIEUID=MEDITERRANEE
http://www.previmer.org/previsions/vagues/modeles_mediterranee/%28typevisu%29/map/%28zoneid%29/menor#appTop
http://www.eurometeo.com/italian/ww3-lamma/jump_LAMMA-0

In addition to these online information, an essential element comes from the real-time meteorological observations provided by the "Azur" buoy (managed by the French weather forecast Agency, Meteo France), located 2 nautical miles from the BOUSSOLE mooring.

The strategy consists in checking the information provided by the above list of weather forecast web sites against the truth, as provided by the meteorological buoy, during the week before the operations. This strategy allows the general evolution of the meteorology to be understood, as well as the stability of the meteorological situation to be evaluated.

2.4 General management issues

A briefing with the ship captain and quartermaster took place at La Seyne-sur-Mer on June 16th 2016 to overview all the steps of the operations to be completed at sea. On the same occasion the major part of the equipment used in the deployment of the mooring line (cable, ropes, acoustic releases, floatation's etc.) was transported from Villefranche-sur-Mer to Foselev Marine and stored into the building dedicated to the Antares project (see http://antares.in2p3.fr/index.html for more information). This also allowed to verify the remaining equipment to be purchased before the deployment (shackles and chain). The two main temporary buoyancies of 100 kg and 500 kg, and the dead weight used to lower the lower superstructure are provided by Foselev Marine.

A second visit to Foselev Marine was done on June 29th to prepare the 12 Vitrovex floats (verification of glass integrity and replacement of the anodized iron covers) and to couple and test the acoustic release system.

2.5 Communication equipment (satellite phone)

The Castor 02 vessel is not equipped with modern communication (e.g., satellite) equipment.

Many commercial cell phones actually operate from the BOUSSOLE site, however this solution is still not optimal since the signal is not available permanently. A possible solution for communication with the shore is the VHF communication with the Semaphore of Cap Ferrat.

However, there was no need to communicate with land for this specific operation because the exchange of the upper superstructure with the helicopter did not occur.

3 Cruise summary

After loading equipment on the ship (the “Castor 02”), the mooring line was prepared for the deployment on the way to BOUSSOLE.

Weather conditions were optimal at the BOUSSOLE site for the first day of operations, and we started with the dismounting of the instrumented mast from the lower superstructure. The mast was put on board and secured on the ship deck over the zodiac platform (port side).

Then the old mooring line was released and recovered, starting from the 12 Vitrovex floats and finishing with the lower buoy superstructure. Swell increased during the recovery of the line up to 0.6 m (it decreased in the afternoon, no impact on the operations).

After that, the new mooring line was deployed starting from the 100 kg temporary float up to the 10T dead weight. Once the line was at sea, the lower superstructure was lowered with the help of a 4-T dead weight and divers attached it to the mooring line and fixed a small white buoy to ease the identification of the deployment point. Then they dismounted a part of the exceeding chain from the line, this operation completed the first working day. The upper plate of the lower superstructure was at 8.2 m depth.

The second day the weather conditions were very good. Divers lowered the floatation sphere by about 0.9 m with the help of the 4T dead weight, in order to reach the desired optimal depth for the upper plate of the floatation sphere (9m). Finally the mast was redeployed at sea, put in the vertical position and then fixed to the lower superstructure.

The operations were completed by switching on the BOUSSOLE battery underwater and the solar panels junction box on the buoy head, then the ship left the mooring site heading to La Seyne-sur-Mer.

4 Detailed cruise report

People on board from LOV: Vincenzo Vellucci, Eduardo Soto Garcia and Agnieszka Bialek.

Friday, August 26, 2016. Local Time (UTC+2h)

09.20 Departure from Villefranche-sur-Mer to La Seyne-sur-Mer, where the ship is based.
12.10 Arrival at Port Bregaillon. Loading of the equipment aboard the ship and lunch. The departure, is scheduled at 16.00.
14.00 Verification of the raw materials for the mooring line.
16.30 Departure from port, heading to BOUSSOLE. The arrival to BOUSSOLE is estimated at 06.30.
17.00 Preparation of the mooring line. The 20 m upper chain is split into two parts of 15 m and 5 m. Plastic washers are glued on the buoy plate with araldite.
19.30 The port authorities communicate to the Castor that passing north of Levens Islands is banned. The arrival at BOUSSOLE is now estimated at 07.30.
20.00 Dinner.

Saturday, August 27, 2016

06.45 Arrival at the BOUSSOLE site (43°22' N, 7°54' E), the ship increased its speed during nighttime). Weather conditions are pretty good. The buoy is slightly tilted, indicating low current. Divers prepare to go at sea.
07.30 The zodiac is deployed and divers go on the buoy to switch off the Junction Box and dismounting the buoy mast.
08.10 The buoy mast is dismounted and floating at surface (**Pic. 3**).
08.30 The buoy mast is trailed close to the Castor and lifted with the crane (**Pic. 4-6**).
08.45 The Castor stands about 350 m away from the BOUSSOLE position. The mooring line is released at the first attempt and the lower superstructure comes up at surface (**Pic. 7**). The ascent of the acoustic releases towards the surface is monitored by interrogating them at regular intervals.
09.00 The buoy mast is onboard and fixed on the ship deck over the zodiac platform. The headlight on the buoy mast was flood (**Pic. 8**) and the antifouling paint suffered strong degradation. A boat is rapidly approaching the lower superstructure and has to be stopped by the Castor 02 captain.
09.15 Orange floats at surface. Preparation to recover the mooring line.
09.40 The zodiac reaches the mooring line and brings it close to the ship for starting its recovery (**Pic. 9**).
10.40 Start of the recovery of the Kevlar cable (**Pic. 12**). The swell has increased to about 0.6 m.
12.00 End of the Kevlar cable recovery, the lower superstructure is partially put on board to remove the chain and the strain sensor. The general condition of the structure is good, though a lot of fouling is present on the structure itself and the first meters of the Kevlar cable. Signs of wear are present at one of the interfaces between the structure and the strain sensor. The ARGOS emergency beacon is dismounted too.
12.50 The lower superstructure is moored on the port side of the Castor 02. The depth at which the two chains, in between the Kevlar cable and tension meter, have to be attached is estimated as: 10.98 m (lower superstructure) + 2.85 m (chain + strain and shackles) + 8.30 m (position of the top of the lower superstructure before receiving the mast weight) + 1 m (security) = 23.13 m and adjusted to 24.00 given that this depth has been generally underestimated in the past.
13.00 The two Kevlar cable drums are exchanged on the winder.
13.30 End of the cable drums exchange and recovery of the pCO2 and O2 sensors on the lower superstructure.
14.00 Lunch.
14.50 Resuming operations. The recovered upper chain allowed to measure the exceeding length being 15 m. I was then decided to further split the upper 20 m chain into 3 parts of 11 m + 4 m + 5 m. The ship moves to 3 km away from the release point.
15.30 Data download from the 2 pCO2 sensors and CTD at 3 m.
15.45 The small (100 kg) float with the 70 m textile rope is deployed (**Pic. 20**). The zodiac is at sea and keeps the line away from the ship.
15.55 The big (630 kg) float is deployed with the 20 m chain (**Pic. 21**), soon after the Kevlar cable deployment starts (**Pic. 22**).
16.30 The emergency ARGOS beacon with new batteries is mounted onto the new lower superstructure along with the pCO2 and O2 sensors.

17.05 The Kevlar cable is completely unwind, its lower termination is fixed to the chain. The 10 T dead weight is secured with the 25 T winch.
17.07 The orange floatation sphere and acoustic releases are deployed (**Pic. 24**).
17.10 The 4 support feet are cut off the ship deck (**Pic. 25-26**) the ship heads to the deployment point.
17.16 The sling is cut and the dead weight dives.
17.30 Preparation of the lower superstructure on the 25 T winch and of the 4 T dead weight on the 5 T winch.
17.40 Recovery of the F3 fluorometer on the 9 m buoy arm.
17.50 The 100 kg float is recovered on board and the line is kept with the port winch through the 70 m textile rope (**Pic. 28-29**). The rope tension is progressively increased to 2.7 T. This is verified through the tension display. During this operation, the ship should be as close as possible to the exact vertical of the mooring point where the dead weight ended up sinking.
18.35 Tension on the rope is stabilized Divers prepare to go at sea (**Pic. 30**).
18.55 The 630 kg float is at surface and loaded onto the ship (**Pic. 31**). Divers on board.
19.35 The 5 T dead weight and the new lower superstructure are deployed (**Pic. 32**).
19.45 The structure is at sea, divers go again at sea. The lower superstructure is detached from the 25 T winch and lowered with the help of the 4 T dead weight.
19.58 The lower superstructure is completely underwater. The upper part of the sphere is clearly visible from the surface.
20.10 The 4 T dead weight is on board.
20.20 Divers install a small white float to easily locate the mooring position (**Pic. 37**) and dismount 9 m of exceeding chain
20.35 Divers on board, operations on standby. The new mooring position is 43°22.0540 N 7°54.1150 E. The distance from the dead weight release point is only 27 m. The upper part of the lower superstructure is at 8.20 m, it will have to be lowered the day after.

Sunday, August 28, 2016

07.00 Recovery of the operations. Meteorological state is excellent.
07.40 Divers go at sea to lower the superstructure.
08.15 The 4 T dead weight is at sea.
08.35 The 4 T dead weight is on board. The buoy has been lowered by 0.90 m.
08.45 The F3 fluorometer is mounted again on the 9 m buoy arm after data download and battery exchange.
08.50 Divers on board. Preparation of the mast deployment.
09.25 The mast is lift with the crane.
09.35 The mast is at sea and brought close to the ship stern. Then the lower part of the mast is lifted on board to install leads to ease putting the mast in the vertical position (**Pic. 38**).
10.05 The mast is ready and divers go at sea to mount it upon the lower superstructure.
10.25 The recovered lower superstructure is brought on board.
10.45 The mast mounting is complete (**Pic. 41**).
11.15 VV goes on the buoy. The battery and the Junction box are switched on. An AK attempt of connection with the buoy failed. However at 11.30 the buoy Ethernet connection was open and the sound of shutter of the hyperspectral reference confirmed the buoy functioning.
11.40 All people is on board.
12.10 Departure from BOUSSOLE to La Seyne-sur-Mer.

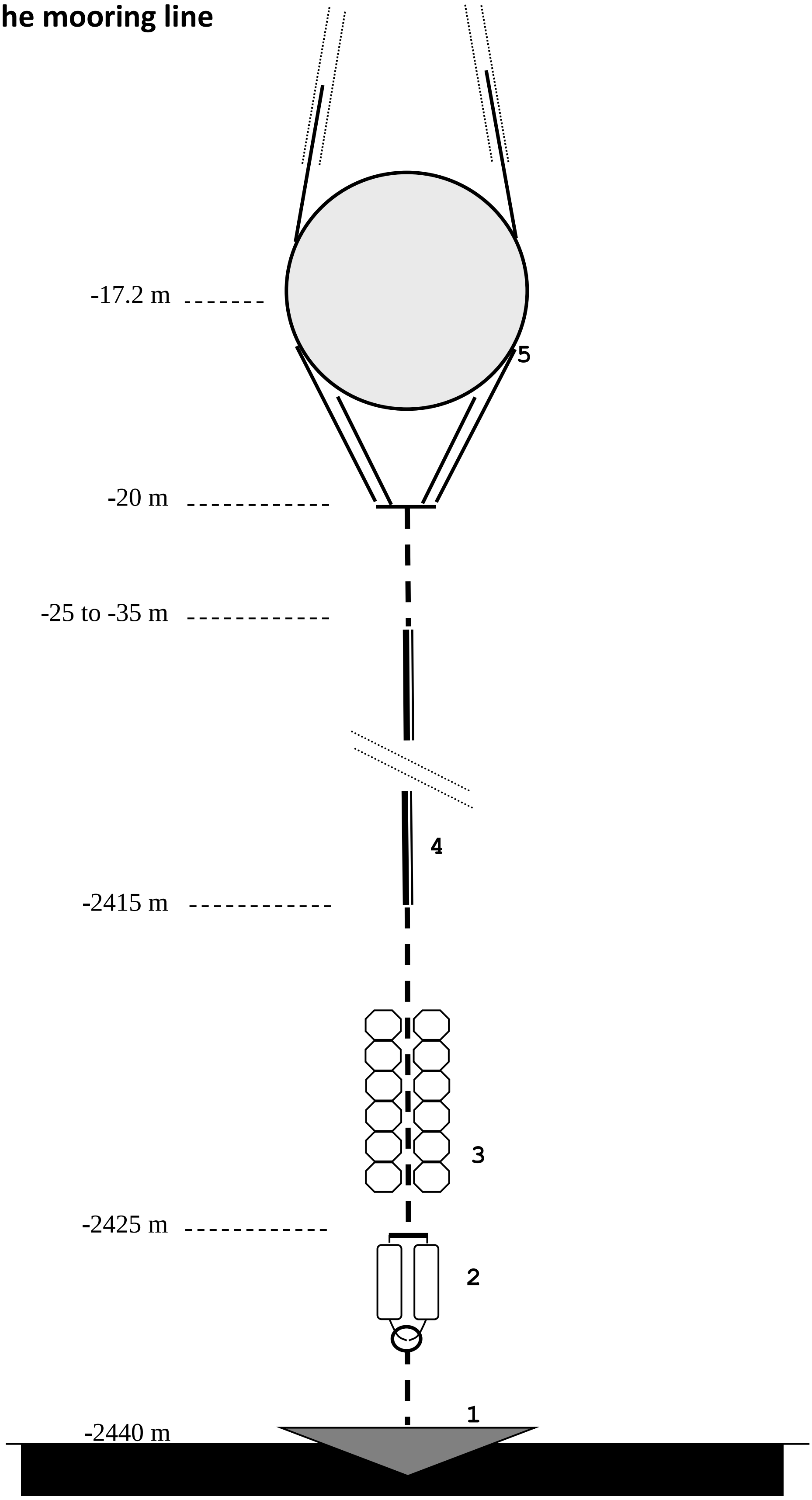
Monday, August 29, 2016

06.30 Arrival at La Seyne-sur-Mer, landing.
08.15 Departure from La Seyne-sur-Mer.
10.40 Arrival at Villefranche-sur-Mer and unloading of the equipment.

5 Difficulties encountered during, and lessons learned from, this deployment

- The ship was not available for almost two months and the captain has been changed during this period. This hopefully did not impact the mission, however such a long report could compromise the mission. However no concrete possibility to overwhelm this type of issues can be adopted since the procedure to set-up the public market for the ship rental is long and money is already engaged at the placement of the purchase order. Nonetheless finding alternative ships for the operations is an option to investigate.
- A problem during the production of the cable occurred on May 25th. The process had to be started again causing some delay in the delivery. Additional delay was due to a wrong delivery of the cable before installation of the two terminations. The whole time lost for these issues was 1 month. Further anticipation of the cable production will have to be considered in the future.
- One of the recovered orange floats shell was damaged. Shell replacement for all floats is recommended. Replacement of anodized iron with stainless steel covers should be considered too.

6 Appendix 1: scheme of the mooring line



Simplified drawing of the mooring line; not to scale. The main elements are numbered as follows: (1) Dead weight (10 T in air, made of a pyramidal steel structure filled with a mixture of concrete and various steel scraps), (2) a pair of coupled acoustic releases (5-T release load), (3) Twelve Vitrovex™ floatation glass spheres protected in plastic shells (total buoyancy 3120 N), (4) 2330 m of neutrally-buoyant Kevlar™ cable (diameter 14 mm; breaking point 12 T), made of parallel Kevlar™ fibers coated into a polyurethane envelope, and equipped at each extremity with a galvanized steel termination, (5) the buoy lower superstructure. Elements symbolized by dashed lines are segments of chain (also galvanized steel), the length of the one just below the buoy being adjusted during deployment while the other ones are predetermined before installation.

7 Appendix 2. Specification for the Kevlar mooring line

Cahier des charges pour le câble en Kevlar (Araline) de la BOUEE BOUSSOLE.

April 2007

Ce projet consiste à immerger une bouée sur un fond de 2440 m. Pour son bon fonctionnement elle doit être en tension constante sur sa ligne de mouillage et émerger d'une longueur déterminée, d'où la nécessité d'avoir la longueur du câble la plus exacte possible, à + ou – 5 m (au pire). Le « réglage » final de la longueur du mouillage se fait à l'aide d'une longueur de chaîne adaptée au moment de la mise à l'eau (chaîne placée entre la base de la bouée et le câble en Kevlar). Voir schéma à la fin du document.

Le câble utilisé a un coefficient d'allongement sous charge, et comme il n'est pas précontraint avant sa pose, il est indispensable de connaître avec une grande précision :

1. Le coefficient d'allongement du câble sous charge, la charge étant représentée par la tension de la bouée (à savoir 28000 Newtons).
2. La longueur du câble au repos, que l'on estime par le calcul, qui sera nécessaire pour constituer la ligne de mouillage.

Pour connaître ces valeurs, il convient de suivre la démarche suivante :

Procédure de calcul de la longueur du câble au repos :

- Profondeur totale sur site : 2440 m
- Profondeur du raccord entre la base de la bouée et la portion de chaîne de longueur ajustable : 20 m
- Longueur de chaîne ajustable : ≈10 m
- Chaîne + Lest entre le fond et le câble Kevlar : 25 m

D'où : LONGUEUR DU CABLE SOUS CHARGE de 28000 newtons: 2385 m.

Problème :

On cherche la longueur du câble kevlar au repos, L, pour sa fabrication :

$$\mathbf{L = 2385 \div coef\ (1)}$$

Pour trouver ce coefficient d'élongation (valeur supérieure à 1) on fabrique un échantillon de longueur L_0, que l'on va soumettre à un essai de traction équivalent à la charge d'utilisation soit 28000 N.

Faire l'essai de traction; on mesure la nouvelle longueur L_1 du câble, et on trouve le coefficient d'élongation :

$$\mathbf{Coef = (L_1 - L_0) \div L_0}$$

Le coefficient trouvé, on calcule la longueur du câble au repos L avec la formule (1).

On procède après la fabrication à la vérification de la longueur du câble par la pesée :

Pour ce faire, on pèse un échantillon d'une longueur L_e mètres (longueur maximale, dans les limites du possible, pour obtenir une plus grande précision ; entre 10 et 20 mètres sans doute). La valeur trouvée est P_e kg. Le câble de longueur L au repos doit donc faire un poids P de :

$$P = (L \cdot P_e / L_e)\ kg.$$

Autrement dit, sa longueur sera :

$$L = (P\ L_e / P_e)\ mètres$$

On suppose que L_e est mesuré sans erreur.

Si le poids du câble n'est pas bon, le câble est raccourci progressivement jusqu'à obtenir le poids recherché (**Attention : une correction dans l'autre sens, à savoir un rallongement, n'étant pas possible, il vaut mieux prendre une marge de sécurité**).

N. B. : l'échantillon servant à la mesure du coefficient d'élongation n'est pas le même que celui servant à la vérification par pesée.

Précision nécessaire pour les balances :

Pour que la vérification par pesée soit efficace (à savoir une erreur de +/- un à deux mètres maximum sur la longueur L, à supposer par ailleurs que le coefficient d'élongation est exact), il faut que la balance utilisée pour peser l'échantillon ait une précision à plus ou moins 1 gramme (si l'échantillon fait 10 mètres, il ne pèsera que 1.9 kg) et que la balance utilisée pour peser le câble entier (qui devrait faire dans les 450 kg) ait une précision à plus ou moins 200 grammes. Deux balances différentes sont donc sans doute nécessaires.

Une erreur de 1 gramme sur la pesée d'un échantillon de 10 mètres (le poids du câble étant de 190 grammes / mètre) se traduit par une erreur de environ 1 mètre sur un câble de longueur L recherchée = 2368 m, par exemple (à savoir la longueur au repos pour un coefficient d'élongation de 0.7% sous 28000 Newtons).

Une erreur de 200 grammes sur la pesée du câble complet se traduit aussi par une erreur d'environ 1 mètre.

C'est donc la pesée de l'échantillon qui est la plus cruciale.

Le ? Avril 2007

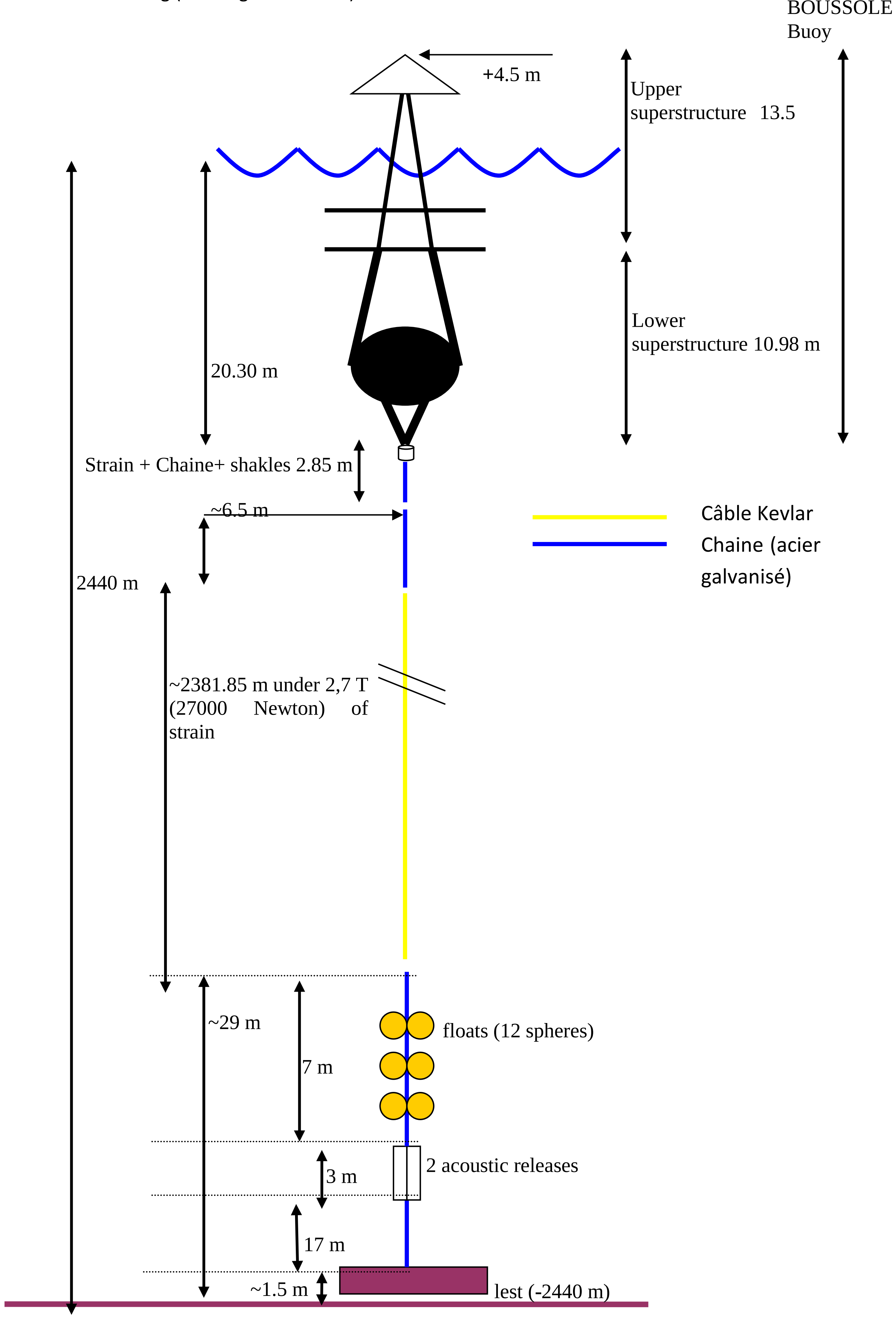
D. Antoine,

CNRS-LOV, Villefranche

Jack Roinsolle,

LAPP-MULLER

Scheme of the mooring (drawing not at scale).



8 Appendix 3. Report of the Kevlar cable construction

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R1463

LAPP GROUP **LAPP MULLER**

Mise à longueur du câble Araline 12T pour le client LOVILL (Laboratoire Océanographique deVillefranche/Mer)

Rédigé par : David AUTERI	Vérifié par : Loïc RAMPI
Le : 04/07/2016	Le : 04/07/2016
Visa :	Visa :

MOTS CLES

- LOVILL
- Cde 39027
- Art 16496
- OF 8574
- Traction
- Araline 12T

SOMMAIRE

Métiers / Activités	Date de diffusion
Direction générale	
Responsable Bureau d'étude	
Responsable R&D	
Responsable Process	
Responsable Equipement	
Responsable Production	
Responsable Achats	
Responsable des Ventes	
Responsable Qualité	
Client : LOVILL	

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1. Introduction

Le Laboratoire Océanographique de Villefranche/Mer (client LOVILL) nous a recommandé 2400 m de câble aramide 12 Tonnes (Article 16496 OF 8574) pour équiper une ligne de mouillage au large de Nice.

Il est nécessaire de mettre à la longueur ce câble de façon à ce que sous 2800 N, sa longueur soit de 2385 m.

Pour ce faire nous devons connaitre l'allongement sous cette charge ainsi que le poids linéaire précis.

Le câble sera mis à longueur avec un **relevage sur l'enrouleur de l'expédition**, puis une pesée viendra confirmer la longueur.

Précédents rapports : R1292 (juin 2013), R1144 (aout 2010), R1000 (juillet 2007) et R904 (mai 2005).
R1286 (mesure allongement des Araline)

2. Tests

2.1 - Etalonnage du banc de relevage des expéditions :

Afin de vérifier le taux d'incertitude du banc de relevage de l'expédition, nous allons mesurer 20m de câble au compteur puis au décamètre (ruban métallique pour limiter l'allongement).

La longueur relevée au décamètre est 20.19m soit une erreur pessimiste de **0.94%** *(0.6% en 2013, 0.5% en 2010)*

2.2 - Mesure de l'allongement sous 2.8T.

Un échantillon de 10.1 m du câble a été équipé d'ancrages puis nous avons fait une mesure d'allongement sur notre banc de traction.

Sous 2.8 tonnes nous mesurons 0.44 % d'allongement *(comme en 2013 (0.4%) mais différemment de 2010 (0.59%) et (2007) 0.57%).*

Ainsi pour avoir 2385m sous 2.8T, la longueur nécessaire doit être de 2385 x (1-0.0044) = **2374.5 m**

2.3 - Mesure de masse.

La pesée de 10.1 m de câble nous donne 185.12gr au mètre (cette valeur est proche de celle en 2013 *(185.36 gr/m) mais éloignée des valeurs trouvées précédemment 191.7 gr/m).*

La pesée du touret après le marquage métrique (après coupe des 20m) nous a donné 437.5kg pour 2426m de câble soit 437.5 kg /2426 m (réel) = 180 gr/m ce qui est éloignée des valeurs trouvées *précédemment en 2013 (190.7 gr/ m) et en 2010 (191.7 gr/m).*

Par conséquent, il a été décidé de se fier au relevage du câble sur l'enrouleur de l'expédition plutôt qu'à la mesure du poids.

Ainsi pour avoir 2374.5m, il faut arrêter le relevage lorsque le compteur affiche 2374.5 x (1-0.0094) = **2352m.**

Le câble a été coupé à 2353m (compteur machine). (Si l'on se fie au marquage métrique du câble, on a 2376 m).

Attention : Le client a clairement dit qu'il est préférable d'avoir un câble trop court que trop long.
S'il est trop court, ils peuvent le rallonger. S'il est trop long, ils ne peuvent plus rien faire (sous l'eau).

2.4 - Test de rupture.

Le test de rupture réalisé à la corderie Dor le 01/07/2016 a donné **11.05T** (Ech. 10m pré-chargé à 3T résiné avec Wirelock) *(précédemment 11T en 2013 et 11.12T en 2010).*

3. Conclusion

Après mise à l'eau le 28/08/2016, le client nous a indiqué que la longueur sous 2.8 daN faisait environ 2382 m ce qui leur a donné satisfaction.

LAPP MULLER

1. Introduction

Le Laboratoire Océanographique de Villefranche/Mer (client LOVILL) nous a recommandé 2400 m de câble aramide 12 Tonnes (Article 16496 OF 8574) pour équiper une ligne de mouillage au large de Nice.

Il est nécessaire de mettre à la longueur ce câble de façon à ce que sous 2800 N, sa longueur soit de 2385 m.

Pour ce faire nous devons connaitre l'allongement sous cette charge ainsi que le poids linéaire précis.

Le câble sera mis à longueur avec un **relevage sur l'enrouleur de l'expédition**, puis une pesée viendra confirmer la longueur.

Précédents rapports : R1292 (juin 2013), R1144 (aout 2010), R1000 (juillet 2007) et R904 (mai 2005).
R1286 (mesure allongement des Araline)

2. Tests

2.1 - Etalonnage du banc de relevage des expéditions :

Afin de vérifier le taux d'incertitude du banc de relevage de l'expédition, nous allons mesurer 20m de câble au compteur puis au décamètre (ruban métallique pour limiter l'allongement).

La longueur relevée au décamètre est 20.19m soit une erreur pessimiste de **0.94%** *(0.6% en 2013, 0.5% en 2010)*

2.2 - Mesure de l'allongement sous 2.8T.

Un échantillon de 10.1 m du câble a été équipé d'ancrages puis nous avons fait une mesure d'allongement sur notre banc de traction.

Sous 2.8 tonnes nous mesurons 0.44 % d'allongement *(comme en 2013 (0.4%) mais différemment de 2010 (0.59%) et (2007) 0.57%).*

Ainsi pour avoir 2385m sous 2.8T, la longueur nécessaire doit être de 2385 x (1-0.0044) = **2374.5 m**

2.3 - Mesure de masse.

La pesée de 10.1 m de câble nous donne 185.12gr au mètre (cette valeur est proche de celle en 2013 *(185.36 gr/m) mais éloignée des valeurs trouvées précédemment 191.7 gr/m).*

La pesée du touret après le marquage métrique (après coupe des 20m) nous a donné 437.5kg pour 2426m de câble soit 437.5 kg /2426 m (réel) = 180 gr/m ce qui est éloignée des valeurs trouvées *précédemment en 2013 (190.7 gr/ m) et en 2010 (191.7 gr/m).*

Par conséquent, il a été décidé de se fier au relevage du câble sur l'enrouleur de l'expédition plutôt qu'à la mesure du poids.

Ainsi pour avoir 2374.5m, il faut arrêter le relevage lorsque le compteur affiche 2374.5 x (1-0.0094) = **2352m.**

Le câble a été coupé à 2353m (compteur machine). (Si l'on se fie au marquage métrique du câble, on a 2376 m).

**Attention : Le client a clairement dit qu'il est préférable d'avoir un câble trop court que trop long.
S'il est trop court, ils peuvent le rallonger. S'il est trop long, ils ne peuvent plus rien faire (sous l'eau).**

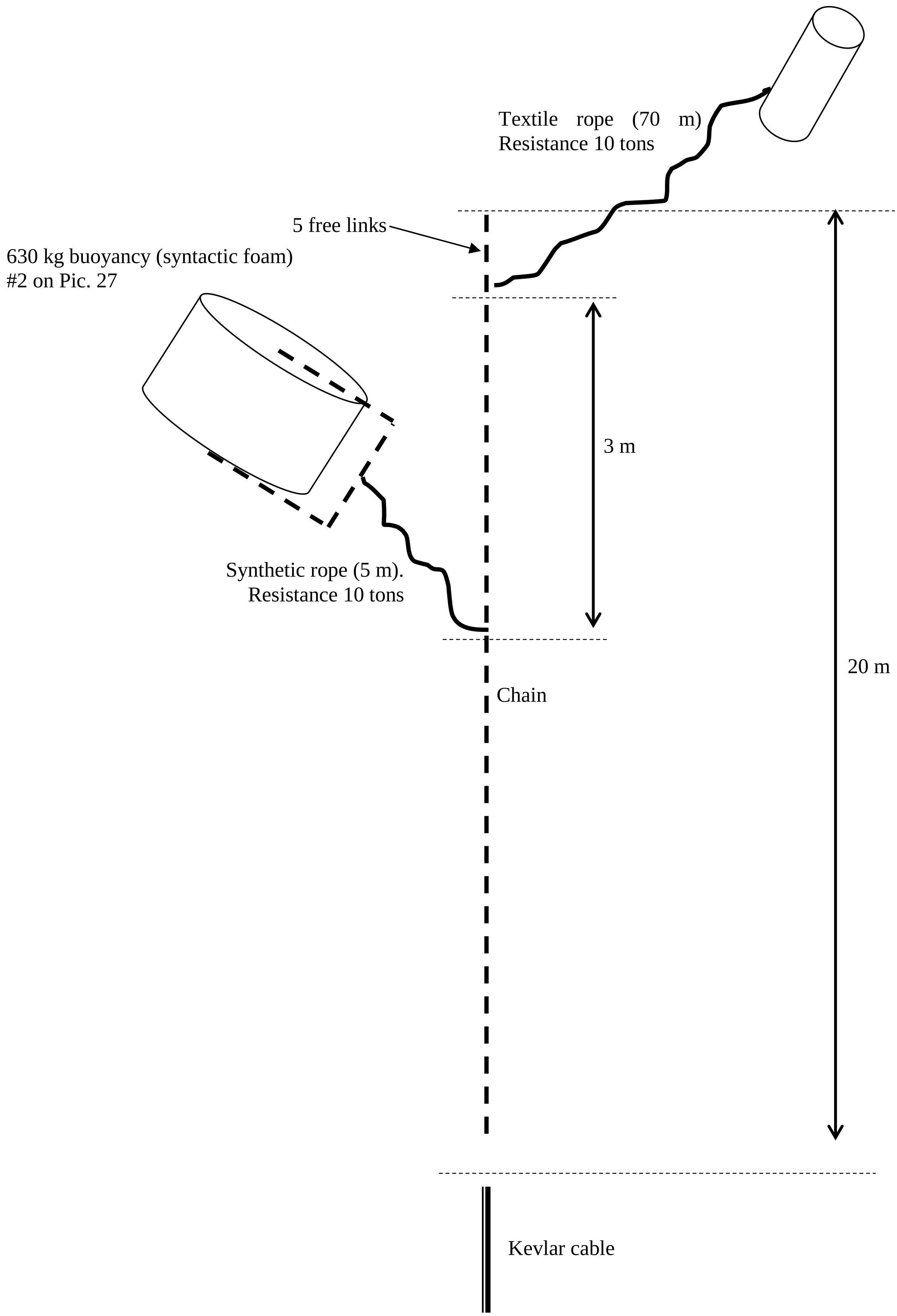
2.4 - Test de rupture.

Le test de rupture réalisé à la corderie Dor le 01/07/2016 a donné **11.05T** (Ech. 10m pré-chargé à 3T résiné avec Wirelock) *(précédemment 11T en 2013 et 11.12T en 2010).*

3. Conclusion

Après mise à l'eau le 28/08/2016, le client nous a indiqué que la longueur sous 2.8 daN faisait environ 2382 m ce qui leur a donné satisfaction.

9 Appendix 4: top of the temporary mooring line



10 Appendix 5: calendar of the sphere preparation

PLANNING PREPARATION BOUEE BOUSSOLE 2013.

TRAVAUX EFFECTUES AU CHANTIER GLOBAL REFIT

AVRIL																											
M3	J4	V5	S6	D7	L8	M9	M10	J11	V12	S13	D14	L15	M16	M17	J18	V19	S20	D21	L22	M23	M24	J25	V26	S27	D28	L29	M30
Mise en place protection pour sablage					Sablage			IOA	Peinture			Peinture							Peinture			Peinture					

MAI						
M1	J2	V3	S4	D5	L6	M7
Férié						
					Départ BIOT + transport	

11 Appendix 6: pictures of the buoy deployment

Link to the full album

Pic. 1

Pic. 2

Pic. 3

Pic. 4

Pic. 5

Pic. 6

Pic. 7

Pic. 8

Pic. 9

Pic. 10

Pic. 11

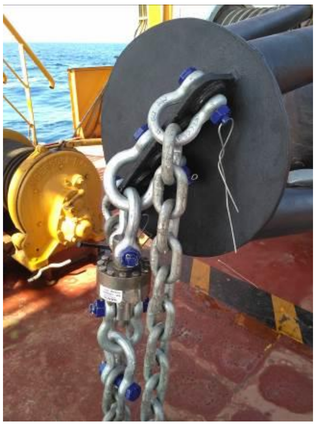
Pic. 12

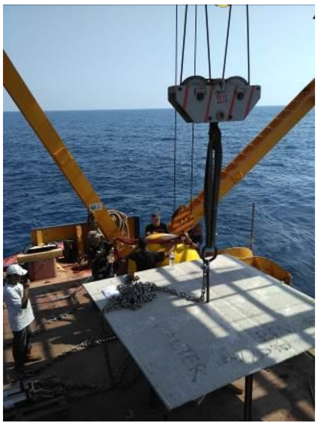
Pic. 13

Pic. 14

Pic. 15

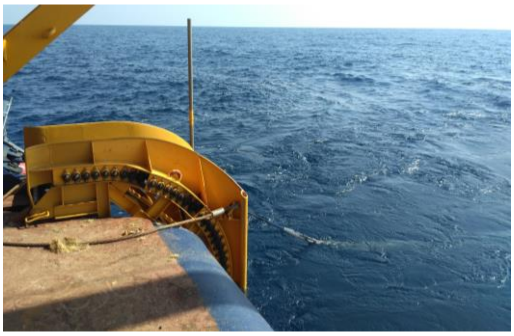
Pic. 16





Pic. 17 Pic. 18 Pic. 19


Pic. 20 Pic. 21




Pic. 22 Pic. 23


Pic. 24 Pic. 25

Pic. 26

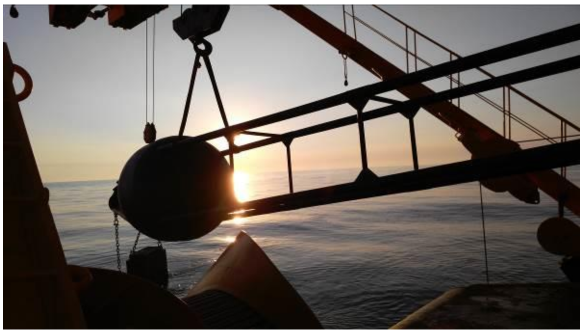
Pic. 27

Pic. 28

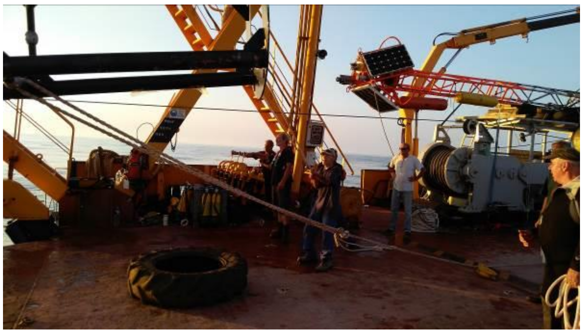
Pic. 29

Pic. 30

Pic. 31



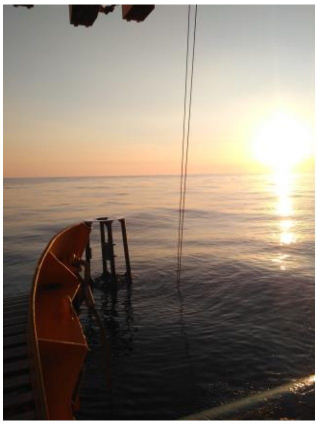
Pic. 32

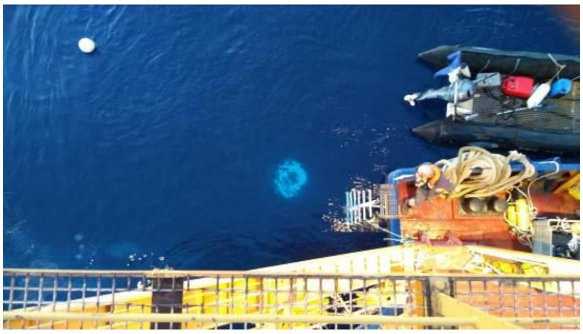


Pic. 33


Pic. 34


Pic. 35


Pic. 36


Pic. 37


Pic. 38


Pic. 39


Pic. 40


Pic. 41

Appendix 7: nominal (theoretical) list of operations for the deployment

The course of the main operations for the deployment of the full mooring line, which necessitates perfectly calm weather and a ship equipped with a dynamic positioning system, is as follows:

1. The mooring cable is unwinded at the surface, starting from its "upper extremity" (the one that will be finally just below the buoy), while the ship heads to the mooring point at reduced speed. The cable is equipped at its extremity with a temporary length of rope terminated by a foam float.
2. The cable is fully deployed a few hundred meters before the ship reaches the mooring point, which reserves some time to deploy the next part of the mooring line (floatation spheres and acoustic releases). Then, the only remaining part is the dead weight.
3. The dead weight is simply dropped in the water at about one hundred meters upstream of the mooring point, so that it reaches this point when arriving at the sea floor after a rapid sink following a curved trajectory because of the drag of the cable.
4. The temporary foam float is then recovered aboard the ship and the cable is progressively put under the desired tension (i.e., about 3 tons) using a winch equipped with a strain gauge.
5. The lower buoy structure (the one with the sphere) is then lowered into the water by ballasting it with the appropriate weight, predetermined before departure on site. Once it is at the desired depth, divers connect it to the chain previously connected at the end of the cable. Two winches are needed during this step, where the dynamic positioning is also mandatory.
6. The tension applied to the cable by the winch is progressively released, simultaneously to the ballast being brought back aboard the ship. The buoy is therefore taking over from the winch to apply the 3-ton tension to the mooring cable. After this step is completed, the lower buoy structure is installed and ready to receive the upper superstructure.
7. The upper superstructure is laid down into the water. It is equipped with floats that are placed so that the buoy is vertical in the water, at about one meter above its nominal water level.
8. Divers bring the section vertically above the lower part, and the connection is progressively obtained by trimming the buoyancy with underwater lift bags. The two parts are attached with simple stainless steel nuts and bolts. Note that all aluminum to steel contacts are isolated using appropriately shaped black Delrin® pieces.
9. If needed, a final trim is performed either by lengthening or shortening the chain below the buoy. This can be done either by using a hoist or by re-attaching some ballast to the buoy in order to slacken the cable. This operation might have to be repeated after the deployment, if current flow during the operation was pushing the buoy down and preventing the equilibrium water level from being reached.

The ideal sequence described above is usually perturbed by some unexpected event (change in weather, faulty parts etc..), which is seemingly the rule when working at sea. Such anomalies occurred from time to time, but have never prevented the buoy from eventually and successfully being deployed.

12 Appendix 8: contacts

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