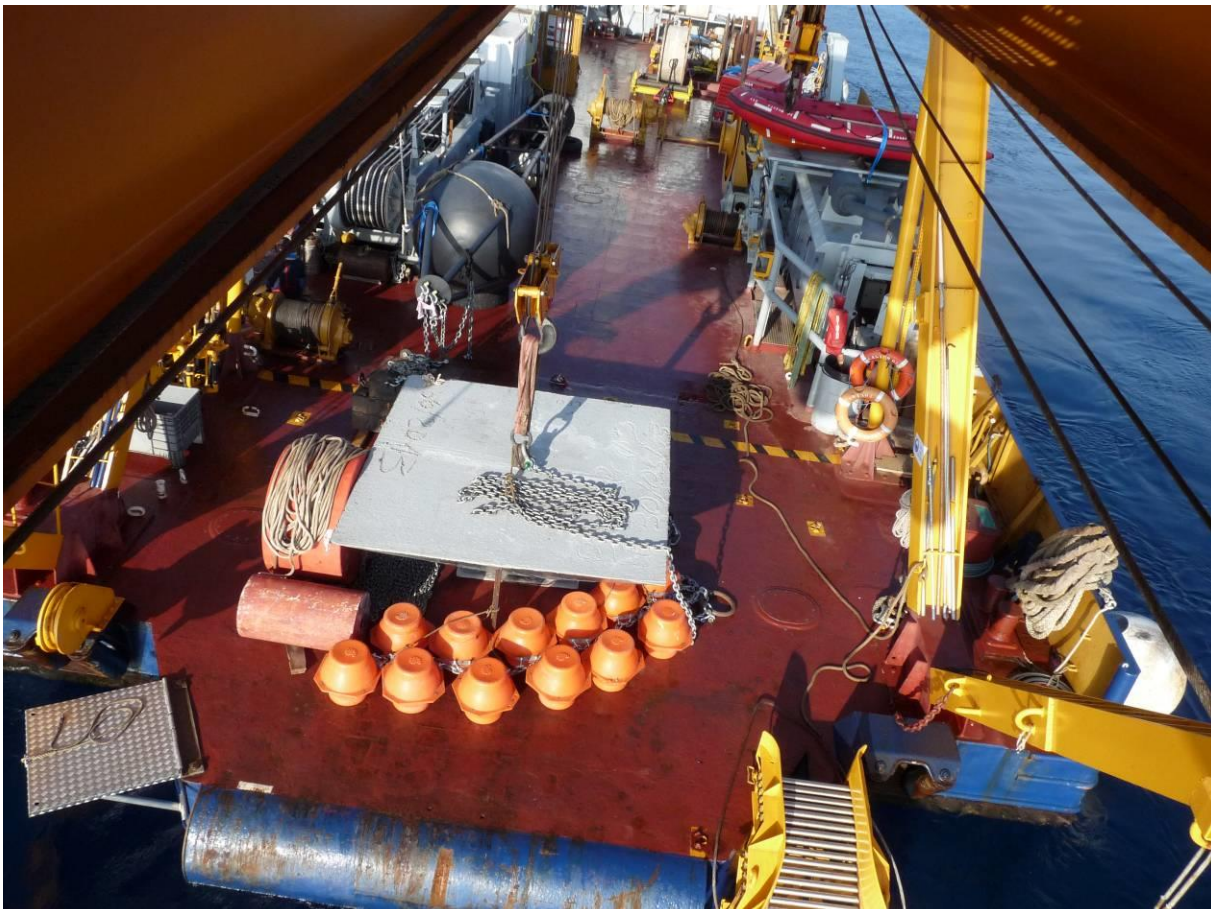
The BOUSSOLE project technical reports

Full rotation of the BOUSSOLE buoy and mooring June 12-14, 2013



Overview of the new mooring line 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 entire BOUSSOLE mooring line and buoy (upper and lower superstructures, see **app. 2** for a schematic view), and to reinstall a new mooring line and buoy.

The last similar operation took place on 23rd to 25th September of 2010. This means the mooring line and the lower superstructure have stayed at sea about 33 months. No particular issues on the Kevlar cable and terminations were noticed after they were retrieved.

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.

Considering the excellent status of all mooring line elements, a rotation every 3 years could certainly be considered in the future.

The first planned available day was May 13th, however due to bad weather the ship calendar was delayed of about 1 month. Mobilization of the CASTOR 02 eventually started on June 8th and the start of operations at sea was on June 12th (see the detailed cruise report below).

2 Preliminary organization before launching the deployment (ship plus helicopter) operations

2.1 Upper superstructure (mast) preparation

This part is described in the buoy deployment log number XV.
Available at: http://www.obs-vlfr.fr/Boussole/html/boussole_data/other_useful_files.php

2.2 Lower superstructure verification and preparation

After the mooring recovery of September 2010, the lower superstructure has been stored at the premises of the "Global Refit" company in Biot (formerly "Chantier Naval de Biot"). The preparation of the lower superstructure took place there under the supervision of Jean François Desté. The preparation started in early April 2013 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 and no defects were found on the sphere and other structural elements, meaning that no extra interventions (repairs) had to be made on the structure.

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 verified that the paint was removed over the contact zones of the anodes before deployment. They also painted the connection plate (i.e., the plate connecting the lower superstructure to the mast) with white paint to ameliorate its visibility from surface after its deployment.

This structure was delivered to FOSELEV MARINE at the beginning of May 2013.

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

When en route from La Seyne-sur-Mer to BOUSSOLE, plastic washers were fixed with araldite on the buoy plate to avoid contact between stainless steel bolts and the buoy, which is made of simple steel (see **Pic. 1**).

2.3 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 counter 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**).

2.4 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
http://www.windfinder.com/forecasts/wind_italy_n12.htm
http://www.meteociel.com/modeles/gfs/resume/3h.htm
http://www.eurometeo.com/italian/ww3-lamma/jump_LAMMA-0
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.

2.5 General management issues

A briefing with the ship captain and quartermaster took place at La Seyne-sur-Mer on March 26th 2013 to overview all the steps of the operations to be completed at sea, and to verify the needed equipment. The parts still to be produced or purchased at that time were: the two main temporary buoyancies of 100 kg and 500 kg, the dead weight and the deck equipment (chain, shackles etc.). The ship company has procured them.

On the same occasion a visit to “Global Refit” in Biot was made to check the progress of the sphere verification, in presence of Jean François Desté.

The major part of the equipment used in the deployment of the mooring line (cable, ropes, acoustic releases, floatation's etc) were transported from Villefranche-sur-mer to Foselev Marine on April 18th with the OOV truck and stored into the building dedicated to the Antares project (see http://antares.in2p3.fr/index.html for more information).

2.6 Communication equipment (satellite phone)

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

Many commercial cell phones are actually operating from the BOUSSOLE site, however this solution is still not optimal since the signal is not available permanently. A possible solution for communication with land in crucial moments of the operations (eg: helicopter exchange) is the VHF communication with the Cap Ferrat Semaphore.

A VHF contact is also established between the helicopter and the ship upon an agreed channel (channel 9 in this occasion).

3 Cruise summary

After loading equipment on the ship (the “Castor 02”), we started coupling the two acoustic releases and to connect them to the mooring line. The command unit of the acoustic releases was put in charge. Note that it has to be kept in charge over at least one night to become operational (the battery should be soon changed), and it is anyway preferable to keep it connected to a power supply when in operation.

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 superstructure.

After that, the new mooring line was deployed starting from the 100 kg temporary float up to the 10 T dead weight. Once the line was at sea, the lower superstructure was lowered with the help of a 5-T dead weight and divers attached it to the mooring line and fixed a small red buoy to identify the deployment point, this operation completed the first working day. The upper plate of the lower superstructure was at 8 m depth.

The second day the weather conditions were still good, with some swell caused by local wind during the night. A telephone contact with Villefranche-sur-Mer was got to define the schedule of transport of the new mast with the helicopter. First the old mast was put at sea, waiting for the helicopter. When the helicopter arrived at the BOUSSOLE site, the new mast was immediately deposed at surface and the old mast loaded for the transport to Villefranche-sur-Mer. The new mast was then recovered on the ship deck and prepared for the deployment.

Divers lowered the floatation sphere by about 1.5 m with the help of the 5 T dead weight, in order to reach the desired optimal depth for the upper plate of the floatation sphere. Finally the new 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 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 and Morvan Barnes.

Wednesday, June 12, 2013. Local Time (UTC+2h)

09.10 Truck rental in Nice (ADA Company, close to Nice railway station).
10.15 Loading of the equipment in the truck at Villefranche-sur-Mer.
10.30 Departure from Villefranche-sur-Mer to La Seyne-sur-Mer, where the ship is based.
14.15 Arrival at Port Bregaillon. Loading of the equipment aboard the ship. The departure, previously scheduled at 15.00 is delayed because of unexpected operations of the crew.
14.45 Coupling of the acoustic releases: the release command, even if plugged, is not capable to send the release signal. The release command battery is then left under charge.
15.30 Plastic washers are glued on the buoy plate with araldite (**Pic. 1**)
18.10 Departure from port, heading to BOUSSOLE. Estimated transit time of 13h.
20.00 Dinner.
23.00 The battery of the release command is charged, the acoustic releases are coupled with the chain and the whole line is ready to go at sea.

Thursday, June 13, 2013

07.00 Arrival on the BOUSSOLE site (43°22' N, 7°54' E). The sky is overcast, wind is very low (3 kt) and the sea is calm. The buoy is slightly tilted, indicating low current (**Pic. 7**).
07.05 The zodiac is deployed and divers prepare for the dismounting of the buoy mast.
07.22 Divers are on the buoy, switch off the junction box and then go at sea (**Pic. 10, 11**).
07.50 The buoy mast is dismounted and floating at surface.
08.05 The buoy mast is trailed close to the Castor and lifted with the crane (**Pic. 12, 13**).
08.40 The buoy mast is onboard and fixed on the ship deck over the zodiac platform (**Pic. 14**).
08.45 The Castor stands at 430 m away from the BOUSSOLE position. The mooring line is released at the first attempt and the lower superstructure comes up at surface (**Pic. 17**). The ascent of the acoustic releases towards the surface is monitored by interrogating them at regular intervals.
09.18 Acoustic releases at surface (**Pic. 18**) and starting the recovery of the line (**Pic. 19-21**). A fishing line is twisted with the Kevlar cable (**Pic. 22, 23**).
11.20 The whole line is onboard and the lower superstructure is detached from the line (**Pic. 24**).

11.30 The OCP#040 is dismounted from the old mast. The pCO2 sensors and related CTD+O2 sensors are also dismounted from the old mast, and the pCO2 is switched off.
11.40 The lower superstructure is temporarily moored on the port side of the Castor (**Pic. 25**), then the two Kevlar cable drums are exchanged on the winder (**Pic. 26**).
12.20 End of the Kevlar cable drums exchange. Mooring of the recovered lower superstructure on the port side of the Castor 02.
12.40 Download of the pCO2 data, then lunch.
13.30 Resuming operations. The new Kevlar cable is fixed to the 500 kg float with a 5 m rope and to the 100 kg float with an 80 m rope (see **App. 4**). The weather conditions are optimal: no wind, no currents, and no waves. The ship moves to 3 km away from the BOUSSOLE point.
14.27 U turn of the Castor 02 to head towards the BOUSSOLE point.
14.30 Zodiac at sea to maintain the mooring line under tension while it is deployed at the surface.
14.32 100 kg float at sea (**Pic. 27**).
14.34 Upper Kevlar termination at sea.
14.35 500 kg float at sea and starting unwinding the Kevlar cable (**Pic. 28**).
15.30 Download data from the recovered CTD and reconfiguration for a restart on June 14th at 17.00 UTC. No communication with the O2 sensor was obtained, the software indicates exhausted batteries; the sensor is not re-installed. Divers put inflatable floats along the recovered mast in preparation of operation of the next day.
15.37 The Kevlar cable is entirely unwind. The lower termination is fixed to the chain. The first of the 4 feet supporting the 10 T dead weight is cut off the ship deck (**Pic. 29**).
15.45 The orange floatation spheres are deployed (**Pic. 30**) and the Castor starts heading toward the established point for the deployment of the dead weight, i.e.: 100 m upstream of the BOUSSOLE position.
16.05 The last dead weight fixation is cut off the deck. The dead weight is secured with the 25 T winch.
16.08 Acoustic releases at sea (**Pic. 31**).
16.12 The sling is cut and the dead weight dives (**Pic. 32-34**).
16.20 The depth at which the two chains, in between the Kevlar cable and tension meter, have to be attached is estimated as: 11.55 m (lower superstructure) + 3.33 m (chain + tension-meter and shackles) + 9.00 m (mast) + 1 m (security) = 24.88 m (**Pic. 36**).
16.35 Recovery of the emergency ARGOS beacon on the lower superstructure (**Pic. 37**). Cleaning of the beacon and battery exchange. The second emergency ARGOS beacon is also prepared to be deployed.
17.40 The 100 kg float is recovered on board and the line is kept with the port winch through a 100 m textile rope. The rope tension should be 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.
17.50 The ARGOS beacons are installed on the lower superstructure. Divers go at sea to detach the 500 kg float from the line.
18.10 The 500 kg float is at surface (**Pic. 39**).
18.25 The 500 kg float is on board. The Castor is 300 m away from the position of deployment of the dead weight, the tension on the rope is 2.2 T. Usually the distance between the deployment and final positions of the dead weight is between 60 m and 80 m. The ship moves slowly towards the deployment position, gradually increasing the tension on the rope.
19.00 The wind speed is at 12 knots and is decreasing.
19.33 When the tension of the line is eventually stabilized at 2.7 T, the ship is at 78 m from the deployment position.
19.45 The temporary 5 T dead weight is deployed with the lower superstructure (**Pic. 40-42**). Divers go at sea.

20.00 The lower superstructure is completely underwater (**Pic. 43**).
20.20 The 5 T dead weight is recovered on board and the tension on the rope is completely released.
20.30 The rope is on board. The sea surface is full of jellyfish (mainly tunicates and cnidarians).
20.42 Divers are on board: the top of the lower superstructure is at 8 m depth and needs to be lowered by 1.5 m. A small surface buoy is attached to the structure with a 9 m rope for its identification.
21.00 Dinner. The wind speed has increased to 15 kt and many caps are present, however the weather forecasts for the day after are good.

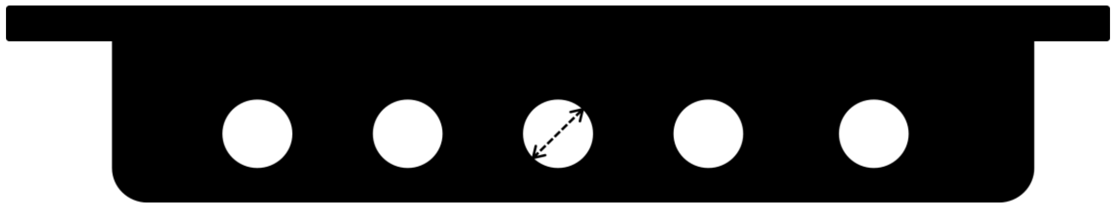
Friday, June 14, 2013

07.00 The weather is good, no wind blows on the site, only a residual swell is present (~0.5 m). Slight current is also indicated by the temporary red float being barely at surface. The recovered mast is prepared for the deployment by divers (**Pic. 45**). Another boat (the "Mouguntia") is now working around the Castor02, with divers/cameramen aboard. They are on site for taking views of the helicopter operations and underwater images around BOUSSOLE after the end of the deployment operations.
07.20 Telephone contact with Villefranche-sur-Mer: the helicopter is scheduled to arrive at BOUSSOLE at 08.45.
08.05 Telephone call from Villefranche-sur-Mer: the helicopter has left the field 10 minutes before what was previously scheduled. The recovered mast is prepared to be re-deployed (**Pic. 46**).
08.10 Telephone contact with Mouguntia to inform of the arrival of the helicopter.
08.20 The mast is at sea.
08.33 The helicopter is at sight view (**Pic. 47**).
08.36 The "new" mast is out down at surface (**Pic. 48-50**).
08.37 The "old" mast is attached to the helicopter sling, and is taken away (**Pic. 51, 52**). Villefranche-sur-Mer is advised of the helicopter departure.
09.01 The "new" mast is on board the Castor 02 (**Pic. 54**). The OCP#040 is mounted on the 4 m arm, caps and protections of the sensors are removed (**Pic. 55**).
09.35 Divers go again at sea to lower the lower superstructure by 1.5 m.
09.40 The temporary 5 T dead weight is at sea.
09.45 The buoy battery is turned on and a connection with the DACNet is set up to adapt the configuration to the OCP#040. A minute of acquisition is run to verify the correct functioning of the system, then the battery is switched off. The adhesive tape is also removed from the arms, connectors and sensors on the mast. The HS4 connector is found unscrewed. Start of the pCO2 sensor and CTD mounting on the mast.
10.15 The 5 T dead weight is on board. The plate onto which the mast should be connected is now at 9.1 m, no currents are present at surface at the moment of the measurement.
10.40 The mast is ready to be deployed. The pCO2 with the cable and CTD are installed (**Pic**. **56**).
10.50 The mast is deployed at surface with divers at sea (**Pic**. **57**).
11.00 The mast is vertical and is being mounted on the lower superstructure (**Pic**. **58**).
11.05 The "old" lower superstructure is brought on the ship deck.
11.40 The marking light is installed on the top of the buoy head. Caps and protections are removed from surface sensors. The transport slings are also removed from the buoy head. (**Pic**. **59, 60**). Divers switch on the battery.
12.50 The junction box is switched on.
13.00 Everybody is on board, the ship heads to La Seyne-sur-Mer.
13.48 Staff members from Villefranche-sur-Mer inform us that data started to be transmitted from the ARGOS beacon at 12.07. The new buoy location is 43°22.0687 N, 7°54.0596 E.

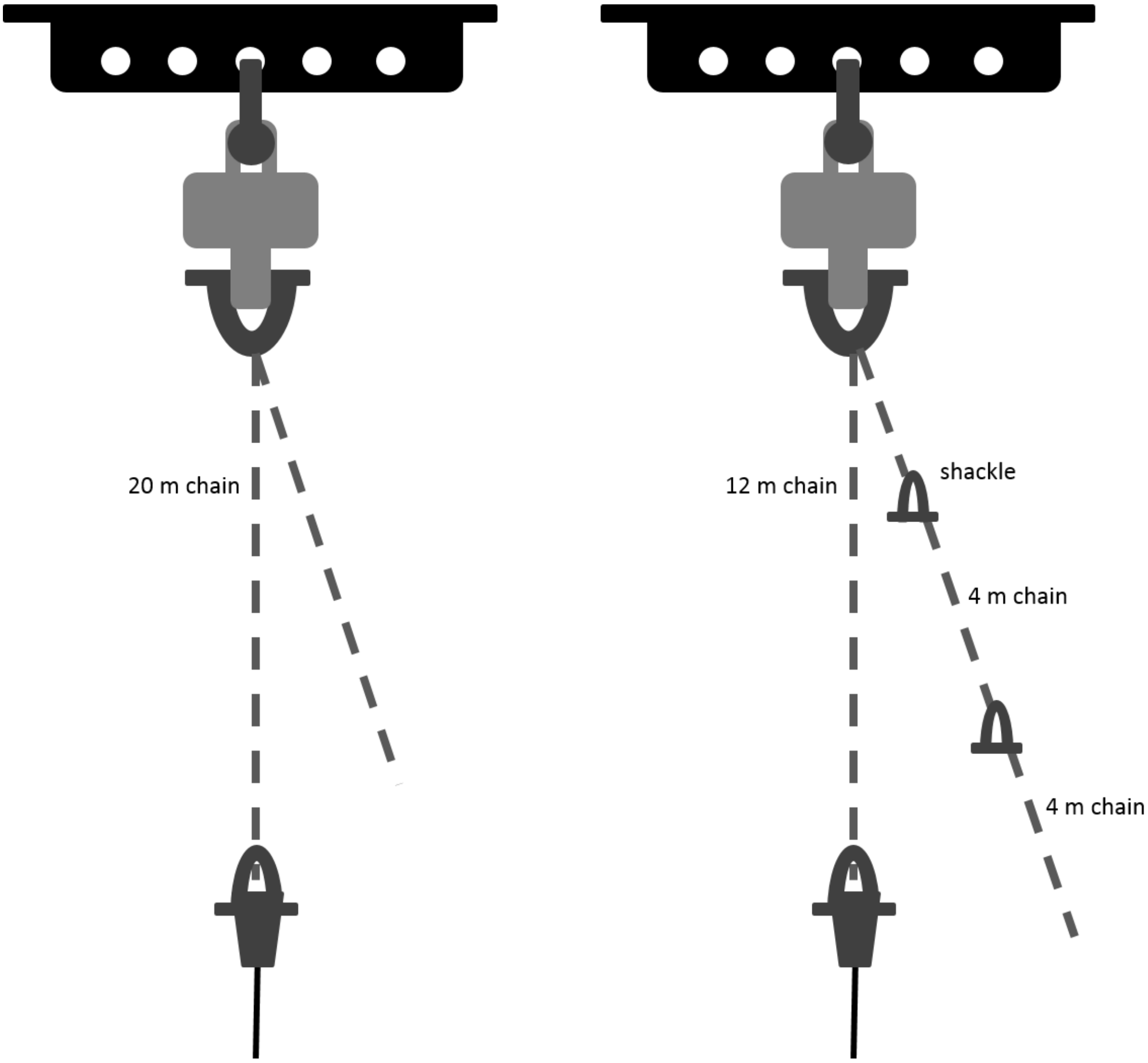
Saturday, June 15, 2013
02.00 The Castor 02 is at dock at La Seyne-sur-Mer
02.05 Loading of the equipment into the truck.
02.35 Departure from La Seyne-sur-Mer with the truck.
04.50 Arrival at Villefranche-sur-Mer and unloading of the equipment.
05.50 End of the unloading.

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

- The diameter of the circular holes on the plaque at the bottom of the lower superstructure (**Pic. 4** and schema below) had to be increased by the crew before departure, because the shackles did not fit into them. The fit between these holes and the shackles to be used should be verified carefully before operations start.

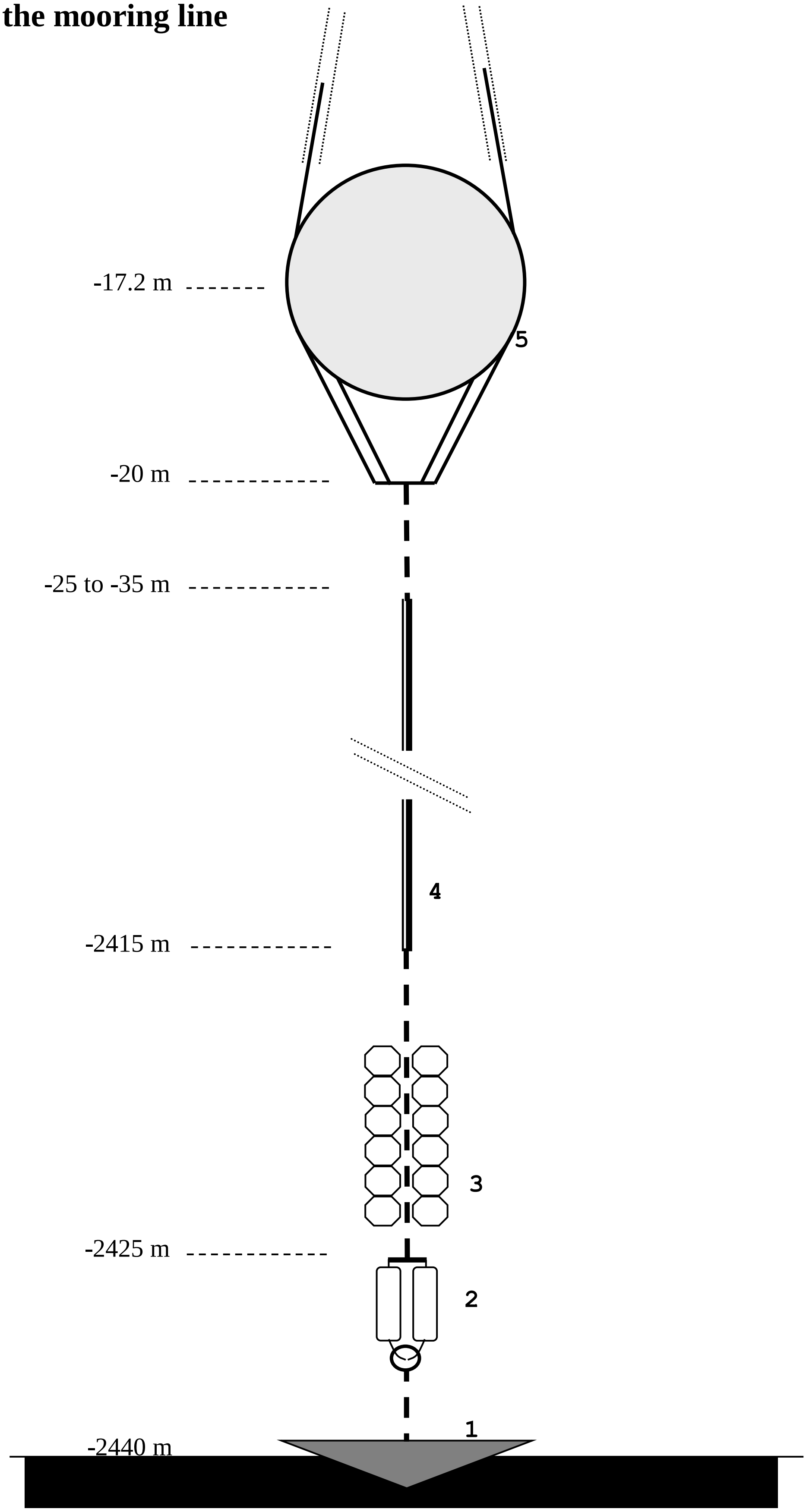


- Once the deployment of the lower superstructure is completed, 10 of the 20 m of chain (see **App. 4**) that links the Kevlar cable to the strain gauge were unused. This excess of chain is actually necessary as a "safety net" in case the Kevlar cable would be significantly shorter than expected. This excess of chain represents a significant weight (~ 80 kg), which could be advantageously removed. A possible solution is to split the 20 m chain into a 12 m and two 4 m parts (see schema below). A second possibility is to cut the unused chain underwater, however this represents extra work and money to rent the appropriate equipment.



- Bringing the tension of the textile rope to the desired 2.7 T (phase 6 in **App. 7**) took a lot of time because the ship had drifted away from the mooring point after the deployment of the 10 T dead weight (~300 m). The record of past deployments shows that the difference between the position where the dead weight is deployed and the final position of the mooring is ~60-80 m. The correct procedure, used in previous deployments, is to go back to the deployment position before starting to stabilize the tension on the textile rope.

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 tons 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-ton 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 tons), 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 :

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

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 :

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

Autrement dit, sa longueur sera :

$$\mathbf{L = (P\ L_e / P_e)\ mètres}$$

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.

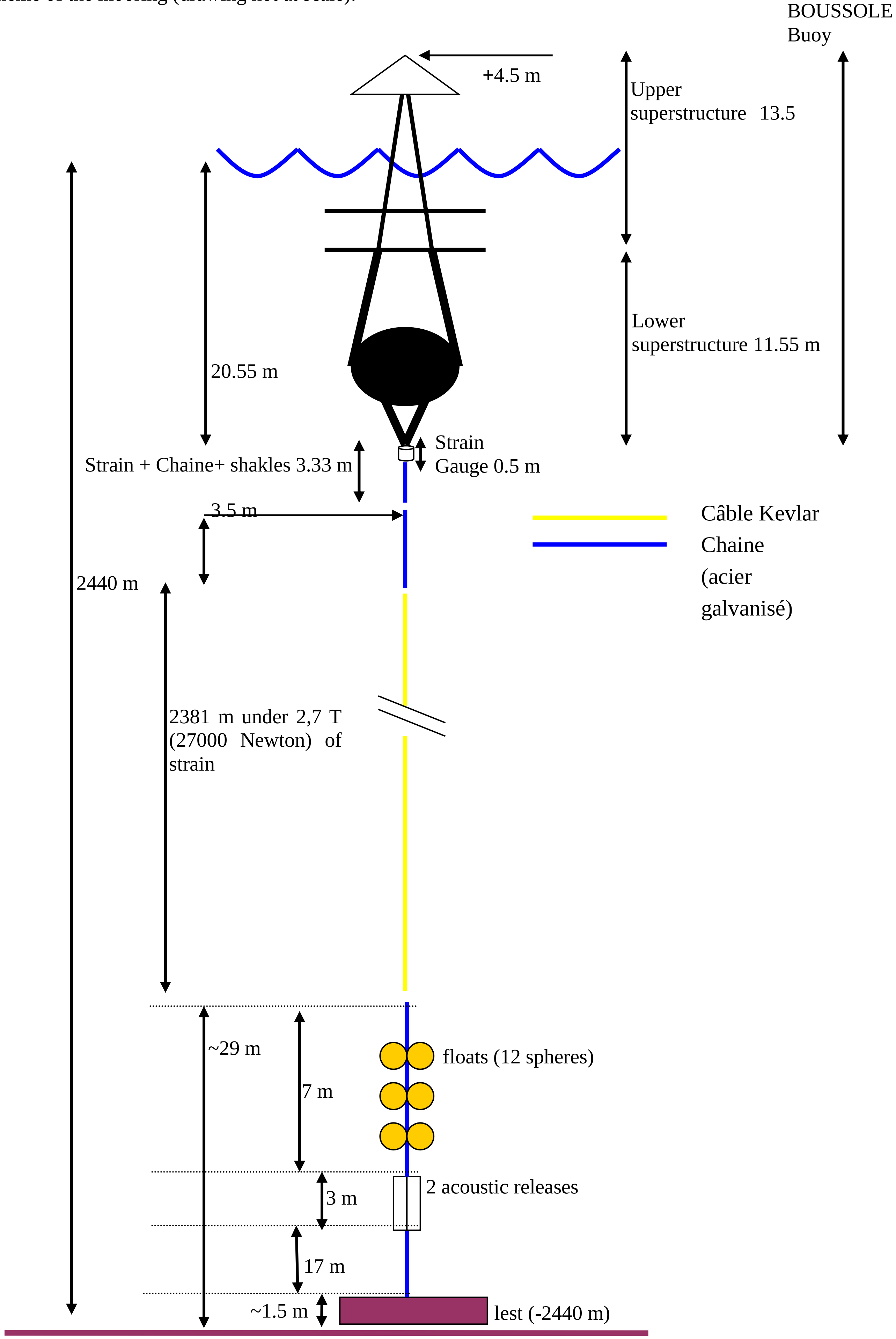
C'est donc la pesée de l'échantillon qui est la plus cruciale.

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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LAPP GROUP

I.27.38
Ind D

Réf. : R 1292

Page 1

MISE A LONGUEUR DU CABLE LOVILL

Rédigé par : **Loïc Rampi**	Vérifié par :	Approuvé par :
Le : 22/04/2013	Le :	Le :
Visa :	Visa :	Visa :

MOTS CLES :

- LOVILL
- ART 16496 -

SOMMAIRE

1 – INTRODUCTION
2 – TEST
3 – CONCLUSION

SERVICE / SECTION	DIFF.	ACTIONS	CIRC. (*)	FAIT LE	VISA
Dossier Fournisseur					
Dossier Produit					
Direction Générale					
Direction Commerciale					
Chef Produit					
Service Qualité / Produit					
Service Pôle Technique	X				
Service Production					
Section Technico-Commerciale					
Section Méthodes					
Section Achats					
Section Logistique					
Section Fabrication					
Secteur Contrôle					
Autre(s) à définir : CLIENT	X				

(*) L'exemplaire « circulation » est transmis de destinataires à destinataires concernés par la colonne « Circulation » après avoir lu et visé le document. Le classement final du document est confié au Responsable Dossier Produits.

LAPP MULLER

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Réf. : R 1142 Page 2

1 – INTRODUCTION

Le client LOVILL nous a recommandé 2400 m de câble 12 Tonnes aramide 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.

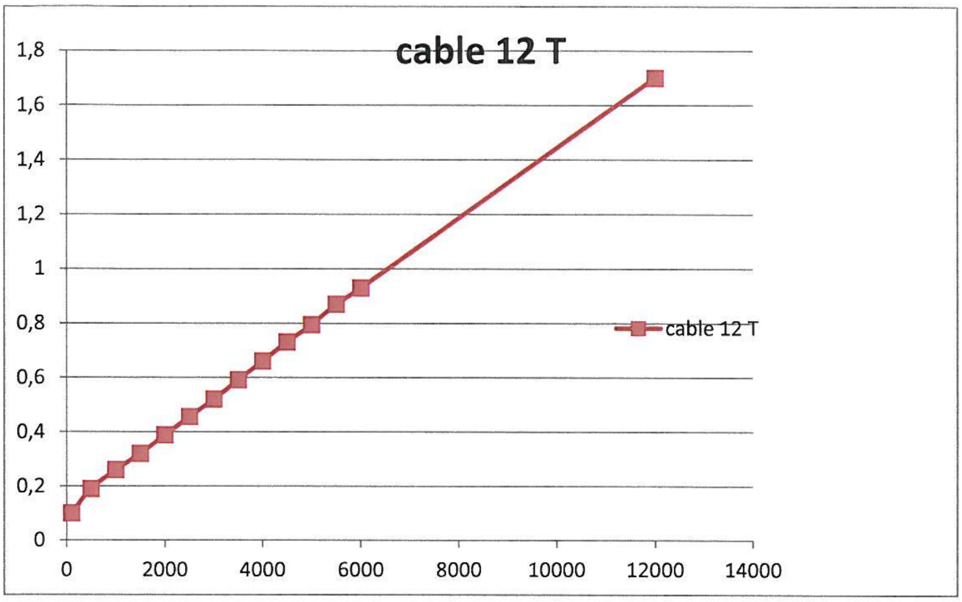
Autres rapports liés R1144 et R1286

2 – TESTS

Monde opératoire de montage :

- MONTER L'ANCRAGE DANS L'ETAU
- ENFILER SUR LE CABLE L'ECROU ET LE LIMITEUR DE COURBURE DANS LE BON SENS
- ENFILER LE CABLE PAR L'ARRIERE
- METTRE EN PLACE LE GUIDE PAR LA CHAPE
- DEGAINER CHAQUE EXTREMITE SUR 8 CM
- EPANOUIR UNIFORMEMENT LA FIBRE
- METTRE EN BUTEE LE CONE BIEN AU MILIEU
- RECOUVRIR UNIFORMEMENT LE CONE DE LA FIBRE
- ACCOMPAGNER L'ENSEMBLE DANS LE GUIDE TOUT EN TIRANT LE CABLE A L'ARRIERE DE L'ANCRAGE
- TIRER FERMEMENT LE CABLE SOUS L'ANCRAGE
- ENFONCER LE CONE AU MARTEAU A L'AIDE DU POINTEAU TOUT EN TIRANT LE CABLE PAR DESSOUS
- MESURER LA PROFONDEUR DU CONE PAR RAPPORT AU DESSUS DE LA CHAPE --> 13MM ENVIRON
- METTRE EN PLACE LES LIMITEURS ET SERRER LES ECROUS
- BRIDER LES 2 ANCRAGES A LA VERTICALE
- PREPARER UN KIT DE WIRE-LOCK
- VERSER DANS CHAQUE ANCRAGE JUSQU'AU RAS DU CORPS
- LAISSER REPOSER 1H

Un échantillon de 10.16 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 0.4 % d'allongement (au lieu de 0.59 % sur la précédente affaire, 0.57 % en 2007) :

La longueur souhaitée est donc 2385 x 0.996 = 2375 m

Le test de rupture réalisé à la corderie Dor a donné 11 T (pour 11.12T en 2010).

La pesée de 6.1 m de câble nous donne 198.36 gr au mètre (cette valeur est éloignée des valeurs trouvées précédemment soit 191.7 gr/m).

<u>Il a donc été décidé de se fier au relevage du câble sur l'enrouleur de l'expédition plutôt qu'à la mesure du poids.</u>

Afin d'avoir une mesure la plus précise possible au niveau de l'enrouleur nous avons coupé une première longueur de 20 m au compteur (20.12 m au décamètre) et une deuxième longueur de 20.11 m (20.23 m au décamètre) sur cet enrouleur.
Dans les deux cas nous avons trouvé que l'**enrouleur était pessimiste de 0.6 %** (contre 0.5 % en 2010). C'est-à-dire que lorsqu'il affiche 20 m le câble fait en réel 20.12 m (+12 cm).

Donc si la longueur souhaitée est de 2375 m il faut arrêter le relevage lorsque le compteur affiche 2361 m.
La pesée du touret après un premier relevage (avant coupe) nous a donné 461 kg pour 2417 m de câble soit 461 kg /2417 m (réel) = 190.7 gr/ m ce qui correspond à la valeur trouvée en 2010 (191.7 gr/m)

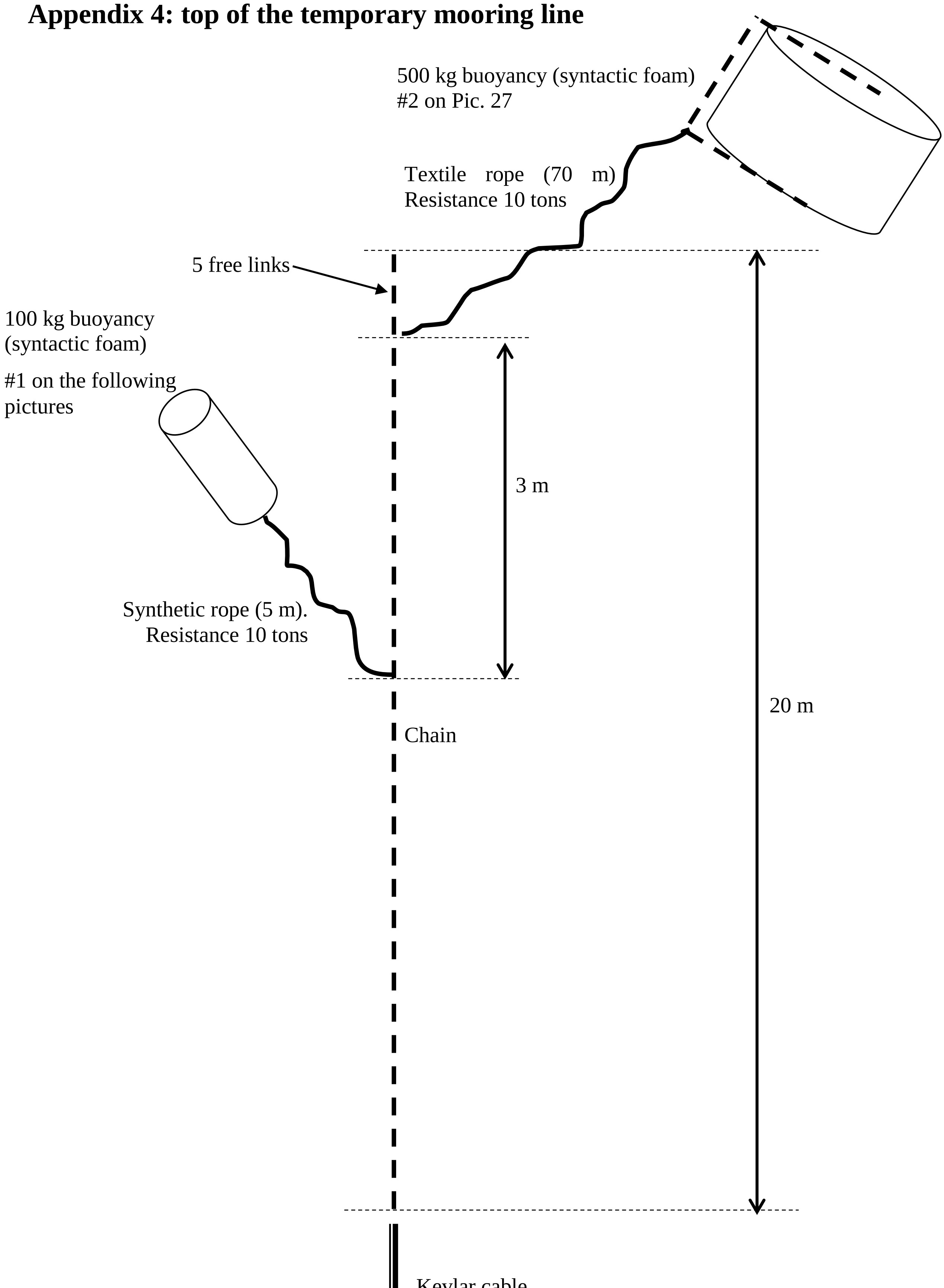
Le câble a été coupé à 2361 m.
(Si l'on se fie au marquage métrique du câble on a 2359 m).

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

2 – CONCLUSION

Après mise à l'eau le 28/06/2013 le client nous a indiqué que la longueur sous 2.8 daN faisait environ 2381 m ce qui leur a donné satisfaction.

9 Appendix 4: top of the temporary mooring line



Appendix 5: calendar of the lower superstructure preparation

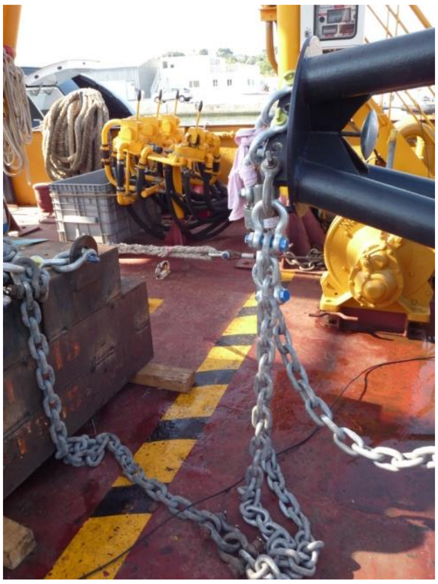
PLANNING PREPARATION BOUEE BOUSSOLE 2013.
TRAVAUX EFFECTUES AU CHANTIER GLOBAL REFIT

AVRIL																												MAI						
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	M1	J2	V3	S4	D5	L6	M7
																												Férié						
Mise en place protection pour sablage					Sablage			IOA	Peinture			Peinture							Peinture			Peinture											Départ BIOT + transport	

10 Appendix 6: pictures of the buoy deployment

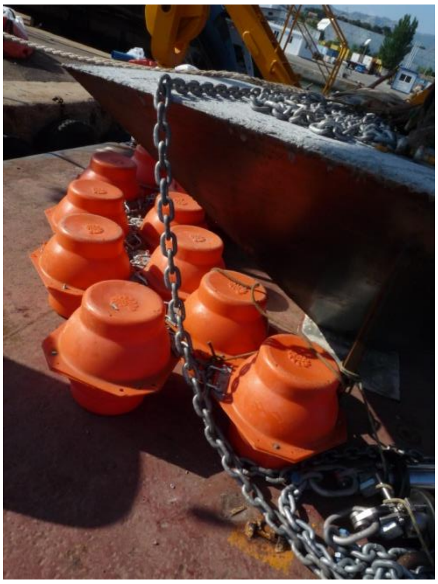
Pic. 1

Pic. 2



Pic. 3

Pic. 4



Pic. 5

Pic. 6

Pic. 7

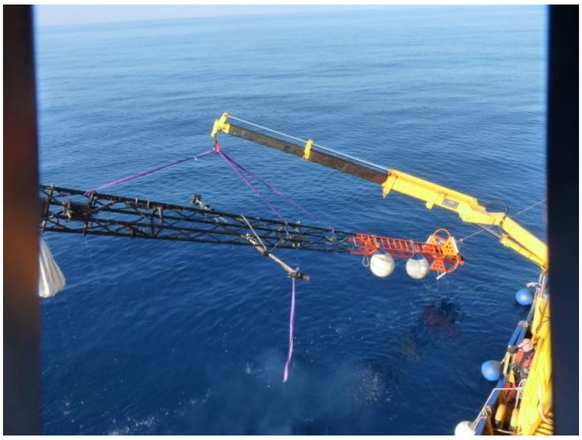
Pic. 8

Pic. 9

Pic. 10

Pic. 11

Pic. 12



Pic. 13

Pic. 14

Pic. 15

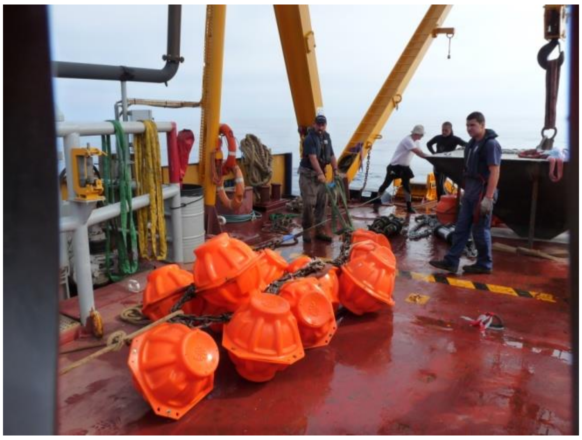
Pic. 16

Pic. 17

Pic. 18

Pic. 19

Pic. 20

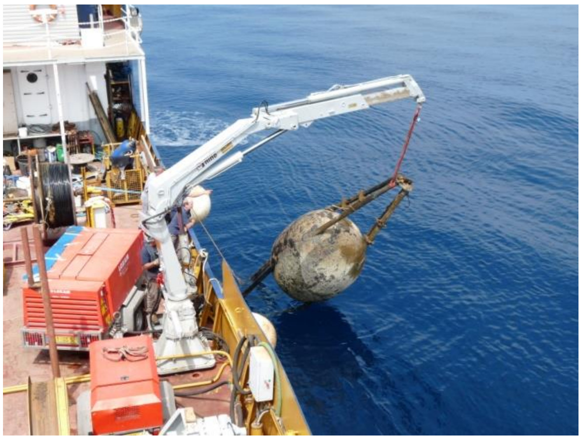


Pic. 21

Pic. 22

Pic. 23

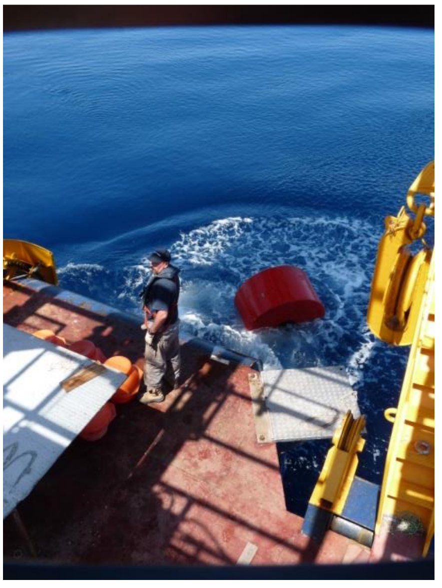
Pic. 24



Pic. 25

Pic. 26

Pic. 27



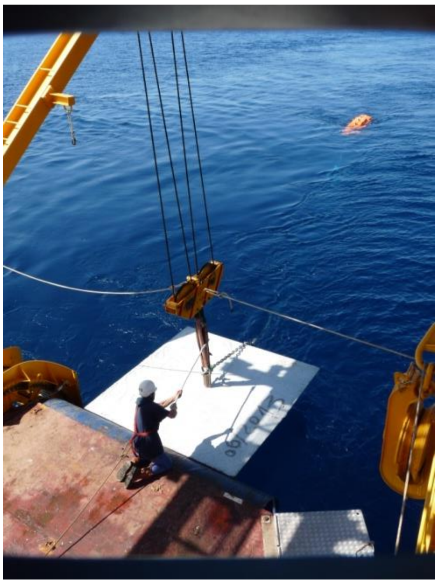
Pic. 28

Pic. 29

Pic. 30

Pic. 31

Pic. 32

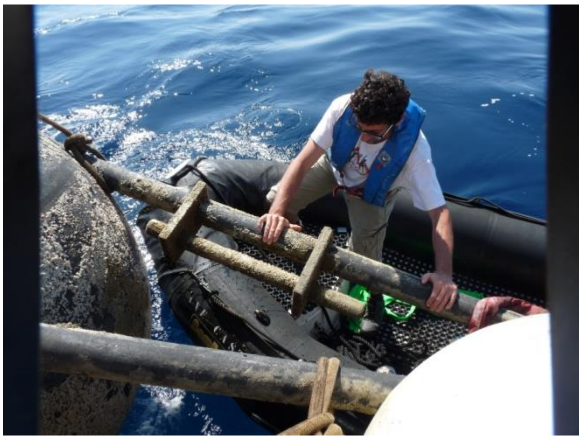


Pic. 33

Pic. 34

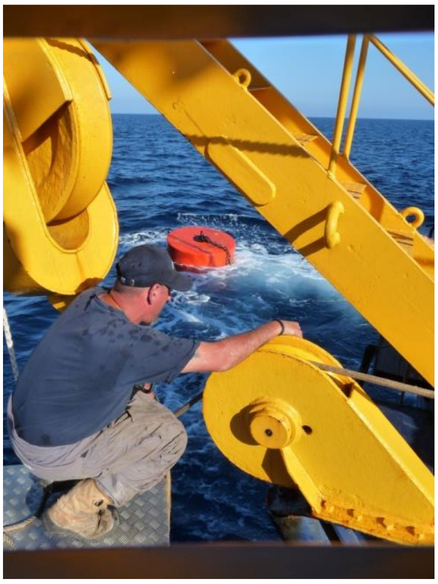
Pic. 35

Pic. 36

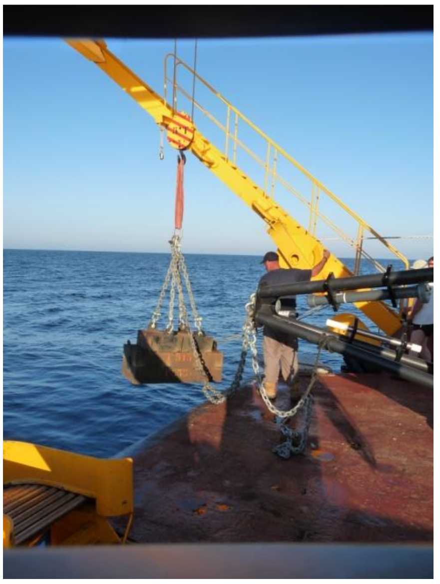


Pic. 37

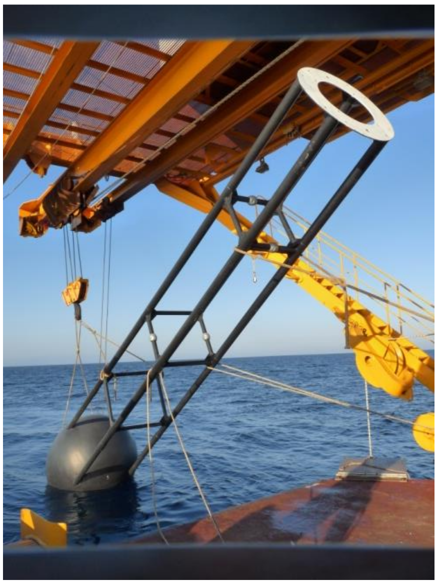
Pic. 38



Pic. 39

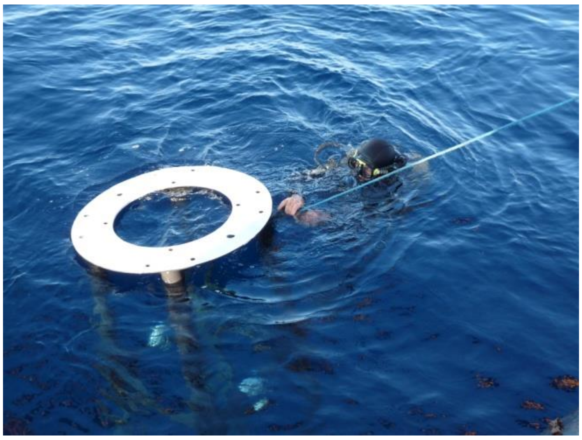


Pic. 40



Pic. 41

Pic. 42


Pic. 43


Pic. 44


Pic. 45


Pic. 46


Pic. 47


Pic. 48


Pic. 49


Pic. 50


Pic. 51


Pic. 52


Pic. 53


Pic. 54

Pic. 55

Pic. 56

Pic. 57

Pic. 58

Pic. 59

Pic. 60

11 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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