Cruise Report cruise 64PE400

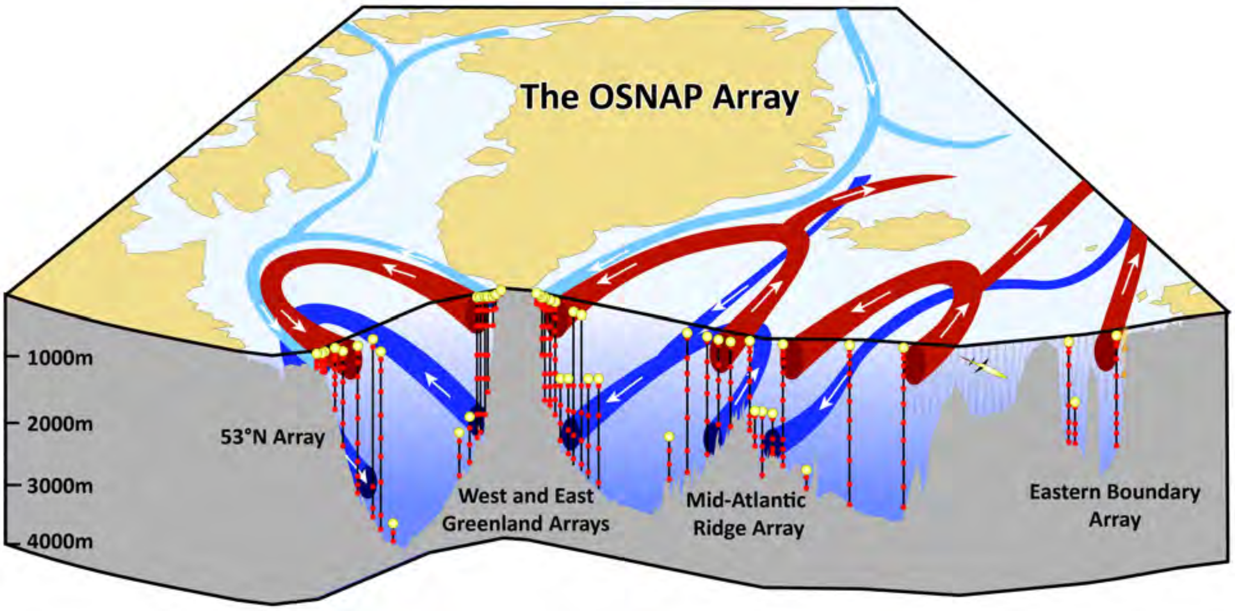
OSNAP East leg 2

July 8-29 2015

Reykjavik-Reykjavik, Iceland

R/V Pelagia

Chief Scientist: Laura de Steur (NIOZ)



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1. Background and objectives

Background

This oceanographic cruise was carried out to support oceanographic mooring operations, hydrographic stations and float deployments within the programs North Atlantic Climate (NACLIM) funded by the EU-FP7, and the international Overturning of the Subpolar North Atlantic Program (OSNAP) East. The cruise was financed by the Netherlands Institute for Sea Research (NIOZ). NACLIM aims at investigating and quantifying the predictability on interannual to decadal time scales of the climate in the North Atlantic/European sector related to north Atlantic/Arctic Ocean surface state (SST and sea ice) variability and change. The program finances the continuation of many long-term mooring sites delivering time series in key areas of the north Atlantic, amongst which the profiling mooring LOCO2 and 4 new moorings on the Reykjanes Ridge. OSNAP is designed to provide a continuous record of the full-water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic and is a large international effort which started off in 2014. The OSNAP observing system consists of two main arrays: one extending from southern Labrador to the southwestern tip of Greenland across the mouth of the Labrador Sea (OSNAP West), and the second from the southeastern tip of Greenland to Scotland (OSNAP East) (Figure 1). During summer 2015 two cruises were carried out with RV Pelagia in the OSNAP East sector: leg 1 covered the Rockall Trough and the Iceland Basin, while leg 2 covered the Irminger Sea between the Reykjanes Ridge and the SE Greenland coast. This cruise report covers leg 2 (cruise ID 64PE400) which was carried out from July 8 to July 29 (red box in Fig. 1).

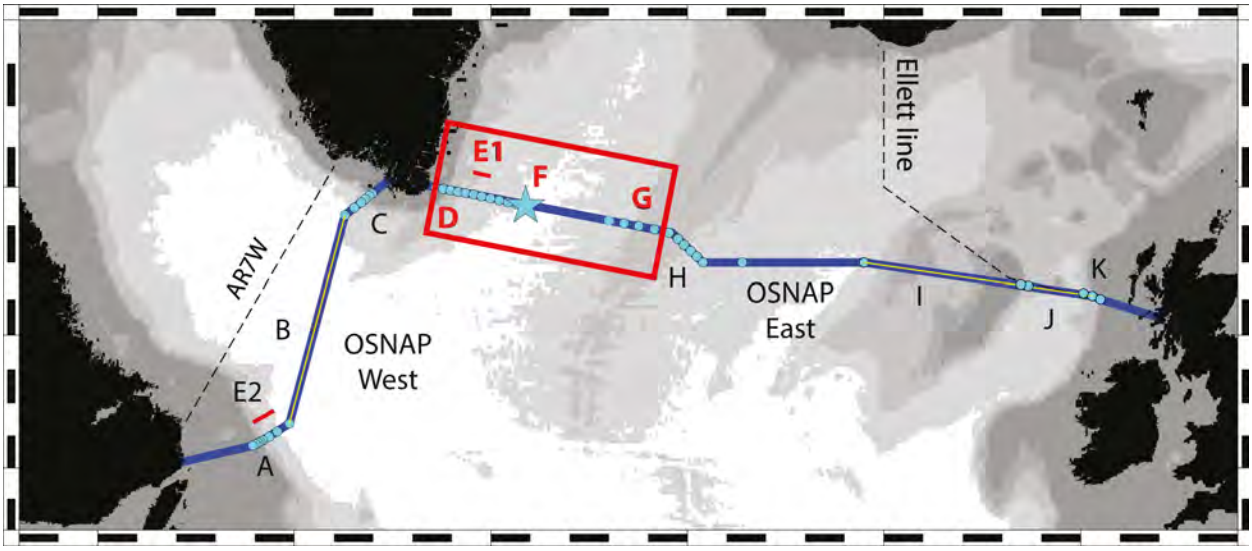

Figure 1: OSNAP East elements to be serviced with RV Pelagia during Cruise 64PE400 in July 2015: (G) Netherlands Western Mid-Atlantic Ridge array; (F) LOCO2 and CIS moorings; (D) UK DWBC array; (E1) US float launch sites.

Cruise objectives

During cruise 64PE400 the OSNAP East moorings, which were deployed in the Irminger Basin in summer 2014 have been recovered, serviced and redeployed (red box in Figure 1). There are 5 moorings in the eastern Irminger Sea in the Irminger Current (IC) maintained by NIOZ, 5 moorings in the Western Irminger Sea in the Deep Western Boundary Current (DWBC) maintained by NOC, and one mooring (LOCO2) in the centre of the Irminger gyre (section 4) maintained by NIOZ. The telemetry buoy from the second mooring in the central gyre (CIS, from GEOMAR) was scheduled to be serviced, but since the telemetry buoy could not be found and was likely broken off or submerged, this activity could not be carried out.

A total of 34 RAFOS floats were released at target depths between 1800 and 2200 m in the eastern and western Irminger Sea as part of the US OSNAP program (section 5). The mooring work was complemented with repeat CTD stations on the former WOCE (or current CLIVAR?) AR7E repeat section (between roughly 59°N, 31°W and 60°N, 42.5°W) including sampling for salinity and dissolved oxygen (O_2) calibration (section 6). On the westernmost CTD stations in the East Greenland Current samples for ∂18O and nutrients were also taken. LADCP and VMADCP data were collected on CTD casts and on the cruise track respectively (sections 7 and 8). Because of good weather and excellent progress an second short CTD section was carried out on the Greenland shelf slope at approximately 64.5°N. On the Reykjanes Ridge between the IC moorings multi-beam data was collected as well on the Greenland shelf slope.

A close collaboration between marine technicians of NIOZ, SAMS and NOC and the ship's crew during the recoveries and redeployments of all moorings allowed for an optimized time schedule and successful mooring operations. All mooring operations were carried out during day time. Three CTD watches consisting of three people each were in charge of the CTD/LADCP stations and the water sampling. They followed a schedule of 12:00-20:00, 20:00-04:00 and 04:00-12:00. All salinity and oxygen samples for calibration of the CTD sensors were measured on board in the salinity/oxygen container by a NIOZ analyst.

2. Cruise participants

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3. Cruise summary

Thanks to an early arrival of the OSNAP East leg 1 (cruise 64PE399) in Reykjavik prior to our leg 2 (cruise 64PE400), and the fact that we were able to shift around all our gear between the two cruises in nearly 1.5 days, made it possible for an early departure on Wednesday July 8th. The daily activities of the cruise are summarized below. The cruise speed of RV Pelagia was generally ~9 kn.

Date	Activity
Tues 7/7/2015	Full day of loading and putting gear in place.
08/07/15	Everyone embarks RV Pelagia at 9 am. Departure at 1 pm from Reykjavik. Transit to mooring site IC4 for roughly 40 hours. Science briefing for everyone on board at 7 pm. Good weather but quite windy, which is slightly tough for some participants.
Thur 9/7/2015	Transit to mooring site IC4. Setting up equipment and labs. Demonstration of CTD/LADCP and water sampling procedures to CTD watches. Still windy and wavy.
Fri 10/07/2015	Recovery of NIOZ moorings IC4 (morning), IC3 (afternoon), and IC2 (evening). All moorings on deck within 1.5 to 2 hours. All look good. One recurring problem was that the SBE37 Microcats on the top 400 m dynema wire had slid down (from ~45 m to 180 m) after a couple of weeks because the tape did not hold properly. Disappointing to not obtain proper temperature measurements high in the water column this year. This is solved by adding 1 m of cable there during the redeployment to attach the SBE37s to.
Sat 11/07/2015	Recovery of NIOZ moorings IC1(morning) and IC0 (afternoon). Start of the CTD/LADCP section on the Reykjanes Ridge at 8 pm. First CTD taken at IC0. Second CTD is also the SBE37 Microcat calibration CTD dip and is done on the deepest CTD cast (7 nm NW of IC0) which is the westernmost station on the high-resolution Reykjanes Ridge section. After that we work our way eastward. Some RAFOS float deployments overnight on locations over 1800 and 2200 m depths. Some wind and waves.
Sun 12/07/2015	Continue the CTD/LADCP section Reykjanes Ridge (stations ~7 nm apart). Salt samples are taken on every cast, while O_2 samples are taken on every other cast. Weather is improving.
Mon 13/7/2015	Continue CTD/LADCP section Reykjanes Ridge. Some problems encountered with LACDP (particularly the slave which is from NIOZ, the master head from NOC is working well). Battery died, was replaced, but the battery case was not tightened properly (a loose end of a zip tie came in between the case and the lid) so that it flooded. Roald and Ruud fixed it very fast. These 'lost' LADCP stations will be repeated during the night between the mooring deployments to obtain good LADCP data there.

Tues 14/7/2015	IC4 got deployed at 10.22 am. A repeat station for LADCP data on the IC3 site was carried out after lunch after which IC3 was deployed. All went well. On both sites the approach to the target site was from the SSE and time for set up was taken to be 2 hours. This was plenty of time since the mooring was ready in ~ 1.25 to 1.5 hours. On IC4 we continued 250 m past the target site, and on IC3 we continued 300 m past the target site before anchor drop.
Wed 15/7/2015	Another successful day with two tall moorings deployments in the Irminger current on the Reykjanes Ridge (IC1 & IC2). Stable (gray) weather gives us very workable conditions. For IC2 and IC1 an approach of 2.5 nm was used and we dropped the anchor at 400 and 500 m past the target position respectively. IC0 was deployed after dinner such that by 21.30 all moorings in the eastern Irminger Basin were done! Time for a little celebration...
Thur 16/7/2015	Just 3 CTDs today, but all deep, wider station spacing and all with a lot of bottles as we take our time to sail across the central basin towards M5 (NOC) which is planned to be recovered the next day.
Fri 17/7/2015	Recovery of M5 and M4 of NOC. Calm weather still though slightly more winds, and colder. Successful recoveries but with slight tangles. All on board by 4.30 pm followed by a calibration CTD cast near M4. 5 RAFOS float deployments during afternoon and evening.
Sat 18/7/2015	We search for the top telemetry buoy from the CIS mooring between 6 am and 1 pm. No sign of the telemetry buoy. Visibility was excellent and wave height was small. It is likely lost. The mooring is still there as we ranged on the releases and triangulation led to the same (± 30m) position as the given anchor site. The CIS mooring site is abandoned after 1 pm and we head to LOCO2 for recovery. LOCO2 recovered at 5.30 pm. MMP has worked very well, as have the Microcats and ADCPs. Directly after recovery of LOCO2 a CTD cast is taken with the two Microcats put on it for calibration. Overnight we go back to the CIS site (5 km distance) and do a CTD there.
Sun 19/7/2015	Start the day with another CTD cast at LOCO2 site (now with the optode on it too for calibration). Work on deck continues to prep for the deployment of LOCO2. After lunch all instruments are serviced and ready to be deployed again. LOCO2 is deployed by 5 pm and the mooring releases are ranged at 3 positions. Final anchor is approx. 470 m from anchor drop which is what was aimed for. One CTD is done at night between M4 and M5.
Mon 20/7/2015	Deployments of NOC moorings M5 (morning) and M4 (afternoon). Done by 6 pm (both positions are ranged). After an initial sunny day the fog picks up and visibility is poor. However, Maarten still gets to go out in the MOB with Len and Fred to film the last bit of the deployment of M4. After that we steam to CTD station 31 which is midway between M4 and M3. CTD done after midnight. Steaming to M3.
Tues 21/7/2015	Today we start with recovering M3 from NOC. Perfect weather, excellent visibility,

	slightly more wind. Released at 08:05, on deck by 10:10 am. After lunch time we continue with M2 for recovery. Released at 12:30, on deck by 14:30. Instrumentation is being read out and Microcats are prepared to go on the CTD for a calibration dip on the M2 site. Overnight: steam eastward again for 5 RAFOS float deployments.
Wed 22/7/2015	Another nice sunny day and calm seas. The day starts with a CTD cast near M3 after which we deploy M3 again. In the afternoon we deploy M2. All NOC moorings are ranged. After that several RAFOS float deployments. No CTDs overnight since the deck team had been up all day and longer. After 8 pm Greenland is in sight, even though still 60 nm away. Very good visibility, and sharp mountain coastline. Hope for continued good visibility tomorrow.
Thur 23/7/2015	Still good weather though slightly more wind, and more clouds. Greenland is not visible anymore. M1 is released ~07:55 and is on deck by 10:15am. Mooring and instruments are all in good shape. Smooth work and smooth sailing. CTD section with ~ 4 nm distance between stations is continued around noon including one calibration CTD dip for the NOC instruments. We plan to CTD throughout the night and continue west into Friday morning onto the shelf. Keeping our distance from the WHOI moorings with ~ 4.5 km. A chart of SE Greenland is found on the bridge. We'll see how far we can get....
Fri 24/7/2015	At 7 am we reached the marginal ice zone... at a bathymetric contour of 1600 m .. Steaming slowly westward, take one more CTD at ~ 1000 m, after which we reach a band of ice with too tightly packed for RV Pelagia to go through ~ at 59°56'N, 42°10'W. Steaming somewhat north and south to see if we can find a way through. Perhaps we need to stop though. Very calm weather and good visibility though cloudy with several layers of very low clouds on the coast. No visibility of Greenland at 30 nm from coast. Too much ice to continue, last CTD station at ~ 480 m on the shelf, just a bit south off the line. We stop the CTD attempts at noon and return to M1 to deploy it late afternoon. Start deployment at roughly 16:20, anchor drop is at 18:50 targeting a water depth of 2085 and taking a fall back of 200 m in account. The anchor position is ranged. As of 7 pm: end of cruise BBQ!
Sat 25/7/2015	Since we have done all the mandatory work on the mooring and CTD line (and more) and still have time left we head north to do another short CTD section across the Irminger Current and East Greenland Current across the Greenland shelf break at roughly 64°N where Dense Shelf water has been found to cascade down the slope. Arrival should be between 6 to 8 am on Sunday.
Sun 26/5/2015	We arrive at the extra CTD section planned across the IC/EGC at ~ 64°N 35°W at 6.30 am. We take 8 to 10 stations across the shelf break between 400 m and 2450 m depth. The shelf is very wide here and warm and salty water is found on the eastern part of the shelf; the EGC appears very far west away from the IC. As there is no time to sample the whole shelf up to the coast, we return SE to at 14:15 pm to pick up at CTD section at 1800 m and

	continue eastward with a last CTD at 2440 m depth until ~ 4 am Monday.
Mon 27/7/2015	CTD line was finished early am. The last CTD/LADCP data is being processed, last salinity and O2 samples analysed and people start cleaning and packing. The day will consist of taking a group photo, sharing and organizing data and text files and compiling the cruise report. Short end-of-cruise seminar at 7 pm about "What have we learned?"
Tues 28/7/2015	Iceland in sight already at breakfast. Steaming into port in the afternoon. Arrival in REY around 17:00.
Wed 29/7/2015	Packing, cleaning and some (WHOI, RSMAS) gear that needs to be shipped is delivered to agent. Some people depart today and most on Thursday.

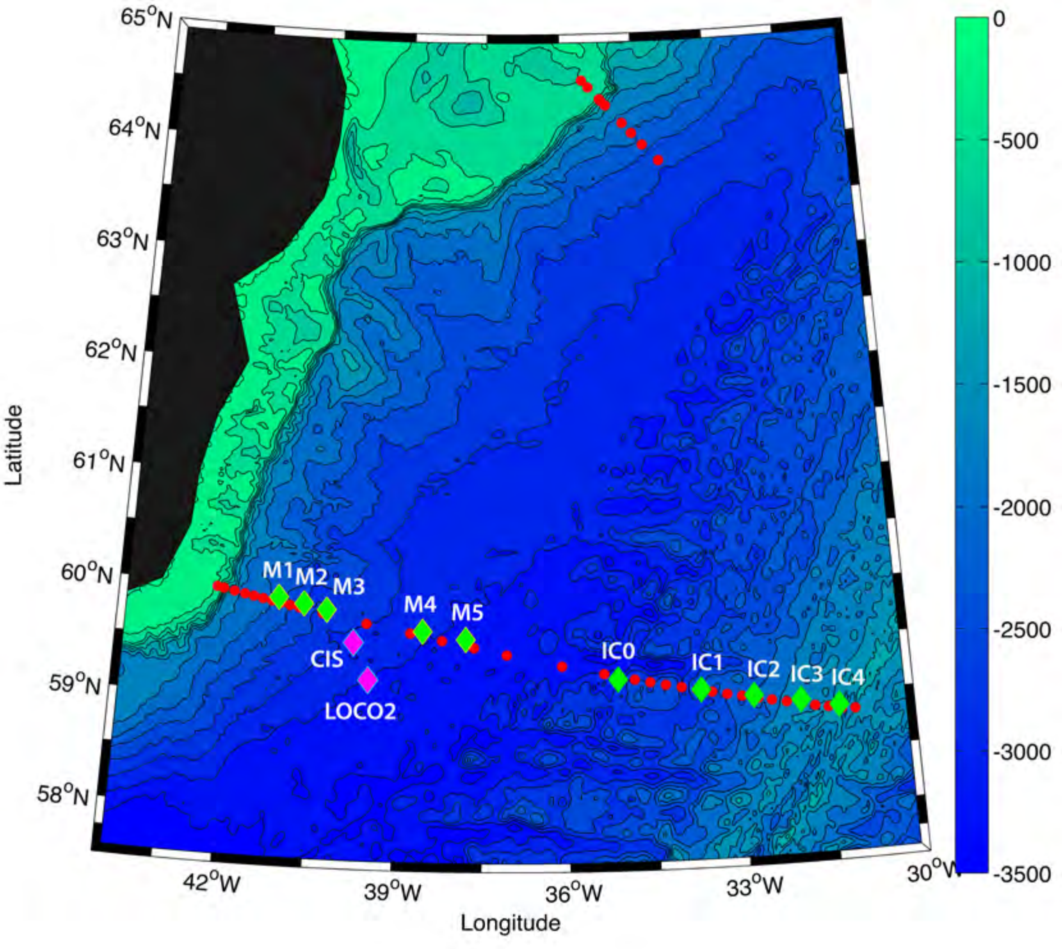


Figure 2: Cruise stations carried out during cruise 64PE400: NIOZ IC moorings IC0-IC4 (black diamonds),NOC DBWC moorings M1-M5 (green diamonds), the NIOZ LOCO2 profiling mooring and the GEOMAR CIS (telemetry) mooring (magenta diamonds), and CTD stations (red dots). The RAFOS float sites were mainly located between M1 - M4, and IC2 - IC0 (see table 2, and Fig. 6.1).

4. Moorings operations (Laura de Steur (NIOZ) and Colin Griffiths (SAMS))

4.1 Notes on mooring recovery/deployment methods

Mooring operations were conducted from the aft deck using a Lebus double-barrelled winch from the Royal Netherlands Institute for Sea Research (NIOZ) (Figure 3). The winch was operated by NIOZ personnel throughout the trip using a remote control unit. The bosun operated the A-frame and the winch controlling the height of the block from a remote control unit. Two crew memberswere on deck to assist with the mooring operations. The crane mounted on the starboard side was controlled by a remote control unit controlled by one of the NIOZ engineers. Three members of the scientific mooring team would assist with moorings operations on deck. Another member of the mooring team was responsible for keeping a log of the mooring operation.

The standard procedure on recovery was for the ship to keep a safe distance from the nominal mooring position whilst the releases were interrogated and subsequently released. The ship would move in closer for the recovery operation once all the buoyancy packages were spotted on the surface. Moorings were grappled adjacent to the wet lab, mid-ships on the starboard side. A line was run from here aft to the Lebus winch. Once the mooring and pickup line was clear of the stern the mooring would be recovered using the Lebus winch. The crane was used for lifting the heavier items on deck during recovery. The standard procedure for NOC was to stop off the mooring line to remove either instruments or buoyancy packages. A sling stopper line with a hook attached was used for this purpose. This was not necessary for the instruments which were clamped onto the mooring line e.g. SBE37 microcats. The procedure for NIOZ was to use a mooring table with a stopper to fit the wire sockets welded on the cable. This allows mooring technicians to work at standing height, and avoids having to kneel on the deck or opening the rear deck gate. This was used for dismounting and mounting the current meters, the SBE37 Microcats and the SBE56 thermistors. For recovery/deployment of the top floats with ADCPs mounted in them the table was moved aside for a short period.

The standard procedure for all deployments was similar to the recovery procedure. The one difference being that for the deployments all operations were carried out from the aft deck. Quick release hook was used for deploying the syntactic spheres, the anchor chain and anchor clump.

Weather conditions were good for all recoveries and deployments. For some of the recoveries the weather was extremely calm. This resulted in some large tangles for the NOC moorings; ideally a wee bit of wind is not a bad thing as it helps to keep the separate buoyancy packages apart.

Figure 3: a) The NIOZ LEBUS Double Barrel Winch, b) the spooling winch used with the DB winch. Photo's: Colin Griffiths.

4.2 Moorings recovered

The four Dutch moorings IC4-IC4 in the Irminger Current (IC) on the Reykjanes Ridge, and IC0 a short - jointly Dutch/US funded - mooring at the bottom of the Reykjanes Ridge were recovered in good order. The locations were chosen such to capture the main branch(es) of the IC (IC1-IC4) as well as the deep boundary current potentially carrying ISOW (IC0). The moorings were initially scheduled to be 5 km NE of the AR7E line, however due to the difficulties of finding a 'good flat spot' for them on the highly variable ridge bathymetry (using multi-beam) IC0 and IC1 almost ended up almost back onto AR7E. The deployment date and time and the final positions/depths of the moorings are given in Table 1.

Name	Recovery date and time	Latitude (degree minutes)	Longitude (degree minutes)	Target depth
IC0-1	11/07/2015	59° 12.88'N	35° 07.55'W	2938 m
IC1-1	11/07/2015	59° 05.93'N	33° 40.93'W	2509 m
IC2-1	10/07/2015	59° 01.23'N	32° 46.05'W	1978 m
IC3-1	10/07/2015	58° 57.33'N	31° 57.54'W	1635 m

IC4-1	10/07/2015	58° 53.12'N	31° 18.18'W	1477 m
LOCO2-11	18/7/2015 ±17:30 GMT	59° 12.048'N	39° 20.241'W	3006 m
M5 -NOC	17/07/2015 ±09:25 GMT	59° 34.8463'N	37° 47.8957'W	3124 m
M4 -NOC	17/07/2015 ±14:37 GMT	59° 38.8709'	38° 34.0344'W	2985 m
M3-NOC	21/07/2015 ±08:00 GMT	59° 48.86'N	40° 16.53'W	2560 m
M2-NOC	21/07/2015 ±12:28 GMT	59° 51.56'N	40° 41.33'W	2429 m
M1-NOC	23/07/2015 ±07:57 GMT	59° 54.175'N	41° 08.457'W	2059 m

Table 1: Mooring positions in the Irminger Sea recovered during 64PE400 in 2015.

4.3 Instrument functioning

IC moorings:

Unfortunately three SBE37 Microcats in the top of the IC2-IC4 moorings slid down after a period ranging from 10 days (IC4) to 3 months (on IC2). These Microcats slid down on the thin synthetic (dyneema) line despite the plastic tape that was first used under the clamps of the Microcats. The Microcats were prevented from further sliding down by the SBE56s at roughly 200 m depth for the remaining of the period (here galvanized tape was used). For the redeployment of these instruments this was prevented to happen again by introducing approximately 2 m of steel cable in the mooring in the top (~60-80 dbar) of IC1 through IC4.

Besides this issue there were only a few instrument failures on the recovered IC moorings:
IC0: The RCM at 2930 m (near bottom) stopped prematurely (26 September) likely due to drainage of battery or due to a bad connection.
IC2: Two RCMs at 720 m and at 1725 m stopped prematurely (22 and 29 September) likely due to drainage of battery or due to a bad connection.

Four SBE37 Microcats from NIOZ/WHOI showed a slight drift during the deployment which was corrected for by comparing with the CTD calibration cast data.

Mooring	SBE37 SN#	Target depth	S correction
IC1	12048	975	-0.00879
IC2	12060	70	0.005771
IC3	12052	70	0.001911
IC4	8511	1300	-0.01446

LOCO2 mooring:

The newly upgraded MMP profiler (new firmware, new CTD) on LOCO2 had functioned exceptionally well during the whole deployment period. Excellent daily profiles were obtained for one whole year. The ADCPs and SBE37 Microcats on LOCO2 had also delivered full records. The additional RINKO optode that was added to the bottom of the mooring to measure dissolved O2 in relation to DWOW showed a large drift during the record and the data is likely not useful. The optode was however recalibrated on board and redeployed. The calibration on board was done with an anoxic solution of demi water with nitrogen. The solution turned out to be not 100% anoxic (10 uM O_2 per liter) and therefore sodium sulfite (Na_2SO_3) should be brought along for that purpose next year (Karel Bakker).

DWBC moorings:

All moorings were successfully recovered. Only two instruments failed to record full data sets. The middle SBE37 on M5-NOC only recorded data up to March 2015 due to battery issues. The 300kHz ADCP on M4-NOC failed to record any meaningful data due to unresolved issues. The ranges of the ADCPs on the other 4 moorings is less than expected especially on M5-NOC (~25m). The ranges on the other three ADCPs is greater during the first half of the deployment (~65m) but then falls off to half of this value for the second half of the records.

4.4 Moorings deployed in 2015

The moorings below are listed in order of deployment (going from east to west). In black the target position is given (for IC moorings) or the position from trilateration (for M1-M5 and LOCO2 moorings). In blue the anchor drop positions and depths are added. The fallback of the mooring after the deployment is also listed whenever available. Detailed mooring drawings are given in Appendices E and F.

Name	Deployed on	Latitude (degree minutes) [anchor drop]	Longitude (degree minutes) [anchor drop]	Fall back (when available)	Depth from multi-beam [at anchor drop]
IC4-2	14/07/2015 10:22 UTC	58° 53.37'N [58° 53.432'W]	31° 17.84'W [31° 18.131'W]		1478 m [1500 m]
IC3-2	14/07/2015 17:19	58° 57.35'N [58° 57.381'N]	31° 57.35'W [31° 57.463'W]		1632 m [1623 m]
IC2-2	15/07/2015 10:19	59° 01.4'N [59° 01.556']	32° 46.63'W [32° 45.999']		1978 m [1988 m]
IC1-2	15/07/2015 15:46	59° 06.26'N [59° 6.507'N]	33° 41.125'W [33° 41.402'W]		2509 m [2485 m]
IC0-2	15/07/2015 21:26	59° 12.99'N [59° 13.024'N]	35° 07.41'W [35° 07.421'W]		2938 m
LOCO2-12	19/07/2015 17:03	59° 12.06'N [59°12.225'N]	39° 30.18'W [39° 29.808'W]	477 m	3008 m [3020 m]
M5 - NOC	20/07/2015 11:16	59°N 34.626'N [59° 34.866'N]	37° 47.952'W [37° 47.857'W]	446 m	3214 m
M4 - NOC	20/07/2015 17:10	59° 38.796'N [59° 38.980'N]	38° 33.941'W [38° 34.145'W]	321 m	2989 m
M3 - NOC	22/07/2015 12:11	59° 48.888'N [59° 51.562'N]	40° 16.59'W [40° 16.214'W]	199 m	2564 m
M2 - NOC	22/07/2015 17:10	59° 51.546'N [59° 51.562'N]	40° 41.334'W [40° 41.551'W]	200 m	2434 m
M1 - NOC	24/07/2015 18:80	59° 54.18'N 59° 54.334'N	41° 6.708'W 41° 06.639'W	296 m	2086 m

Table 2: Moorings in the Irminger Basin deployed during cruise 64PE400 in 2015: the Dutch moorings IC1-IC4, the Dutch/US mooring IC0, the Dutch LOCO2 mooring, and the UK moorings M1-M5 (Note: the latter are given the extension NOC here since the RSMAS moorings in the Iceland Basin are also named M1-M5).

4.5 CIS mooring survey (Till Bauman, GEOMAR)

The CIS-mooring in the Irminger Sea is part of GEOMAR's (Kiel, Germany) contribution to OSNAP. The current version was deployed in late summer 2014 in the southwestern Irminger Sea for a two-year period and is designed to monitor possible deep convection events and their influence on nutrient concentrations. The data of the instruments located in the upper thousand meters of the mooring are inductively send through the mooring wire to a little surface buoy that transmits them via satellite to the headquarters in Kiel. Because this telemetry buoy stopped working in early 2015, it was planned to be replace during this cruise. When the buoy was still working properly, it regularly transmitted its GPS-based position and thus the expected location was well known: A circle with a radius of maximum 400 m centered around the known mooring position 59° 31.05'N,39°W 47.25'W (see Fig.4). On July 17th the search for the buoy began at 6:30am but despite the well-known position, the calm sea and good visibility the search remained unsuccessful. After seven hours spent on a dense search-grid within this confined area, the mission had to be abandoned. A subsequently performed triangulation based on the distances obtained by contacting the mooring releases from different positions confirmed the location of the actual mooring. This means that the mooring is most likely intact; only the surface buoy is missing. It remains uncertain whether the buoy was ripped off the mooring or just went subsurface.

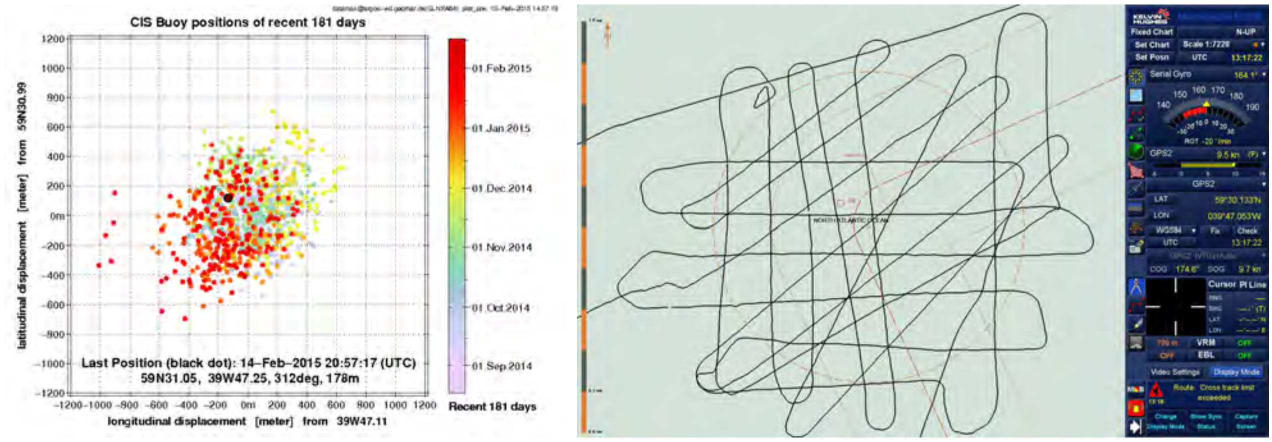


Figure 4: a) The last CIS position in Feb. 2015, b) cruise track when searching for the CIS telemetry buoy.

5. CTD stations (Femke de Jong, NIOZ/Duke University)

A recently (April 2015) calibrated SBE 9/11+ CTD, SN-0942, was used to measure temperature, salinity, and turbidity profiles. The sensors mounted on the CTD were an SBE3 temperature sensor SN-001219, SBE4 conductivity sensor SN-003262, a Digiquatz pressure sensor SN-127486, an SBE43 oxygen sensor SN-0431932, a Wetlab CStar beam transmission meter SN-CST-1406DR with a path length of 25 cm, a Chelsea PAR/irradiance sensor SN-118, and a Chelsea Aqua 3 fluorometer SN-088008.

The CTD was mounted in a special rack, which contained 22 Niskin water samplers. Two Niskin water samplers were taken off the rosette to make space for the dual-head LADCP set up (Lowered Acoustic Doppler Current profiler). To control the temperature measurements an SBE35 Deep Ocean Standards thermometer was mounted next to the temperature sensor of the CTD. Reference temperature samples were taken with this when water samples were taken with the Niskin samplers. At every bottle stop the CTD operator waited one minute to allow the bottle to be flushed properly. After the bottle was closed another minute was waited to allow the SBE35 to register temperature. The water from these samplers was sub-sampled for the determination of dissolved oxygen and salinity on most stations (Figure 3) and for nutrients and δO^{18} on the stations near Greenland.

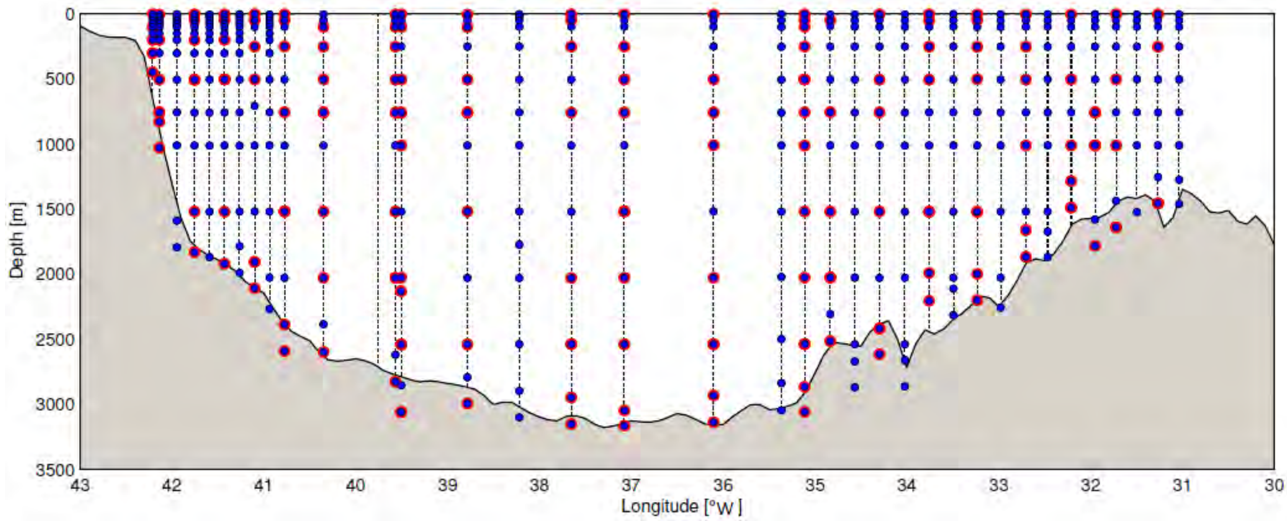


Figure 5. Bottle depths for salinity (blue) and oxygen samples (red) for the 42 CTD stations along AR7E. Nutrient samples were taken from bottles 300 m and up on the western 8 stations. δO^{18} samples were taken from bottles closed in the upper 100m on the same stations. Bottom topography is from ETOPO data set. Bottle samples were taken at every station and indicate actual encountered depth.

For the data collection the new Seasave software for Windows (version V7.21d), produced by SBE, was used. The CTD data were recorded with a frequency of 24 data cycles per second. After each CTD cast the data were copied to a hard disk of the ship's computer network. The CTD data were processed with the recently obtained calibration data, using the Seasoft software, also produced by SBE, and reduced to 1 dbar average ASCII files for regular use and to 1Hz average ASCII files for the LADCP processing. These were used for the preliminary analysis of the data. The final data processing was completed at Royal NIOZ, Texel. In **Appendix A** a list is given with all 51 CTD stations carried out during the cruise. Stations 1 through 42 are on the main section across the Irminger Basin (~AR7E). Stations 43 to 51 are taken on a 2nd section at roughly 64.5°N across the Greenland shelf slope to capture the spill jet.

5.1 Reference temperature measurements

Mounted on the CTD-rack was a high precision SBE35 reference temperature sensor, which recorded the temperature on commands given by the CTD operator. These SBE35 temperature data will be used to control the calibration of the CTD temperature sensor. The difference T_{CTD}-T_{SBE35} amounts to -0.000953°C (±0.0016°C standard deviation). There was no significant drift.

5.2 Salinity calibration

Measurements from the salinity samples were used to calibrate the CTD salinity. The Seabird conductivity sensor is known to show an amplification bias, a pressure or density dependent bias and occasionally a drift in time. The set of sample/CTD salinity values were checked for these types of biases. No significant drift was seen although several stations, CTD# 11 to 16, had somewhat higher biases due to unknown reasons. Both the CTD conductivity and salinity (calculated using the corrected temperature) showed an offset with a slight pressure dependence. Using an adjusted CPcor of 9.35e-08 in the Seabird processing software improved the CTD salinity, but a better match was made with the samples using a direct adjustment of the salinity. The found salinity bias was S_{CTD}-$S_{samples}$ = - 2.0722e-7 *P + 0.002245.

5.3 Oxygen calibration

Measurements from the oxygen bottle samples were used to calibrate the CTD oxygen. The CTD oxygen is known to have amplification issues, but for the 64PE400 cruise we found pressure effects to be dominant. The found oxygen bias was $O2_{CTD}$-$O2_{samples}$ = - 0.00034423 *P – 6.0812.

5.4 Tracer samples

Nutrient samples (PO4, NO3, NO2) and oxygen isotope samples (∂18O) were taken in the EGC/IC on CTD stations 34 and 36 through 42 on section 1, and on stations 43 through 50 on section 2. The nutrient samples were filtered and frozen on board, and are analyzed later at NIOZ. The ∂18O samples will be send to the Vrije Universiteit (VU) in Amsterdam to be measured by a stable isotope mass spectrometer, Finnigan Delta+, equipped with a Gas Bench. These joint tracer data will be used in a three end-member equation to identify the contribution of Pacific Water, sea ice melt and meteoric mater to the freshwater content in the EGC.

5.5 Section plots

Preliminary section plots of temperature and salinity and dissolved ogygen are shown below. Due to a strong winter in 2014-2015 deep convection occurred in the Irminger Sea replacing all the LSW, and newly ventilating the basin. This can be seen clearly as a cold, fresh and high oxygen water mass on the section shown in Figures 6 and 7.

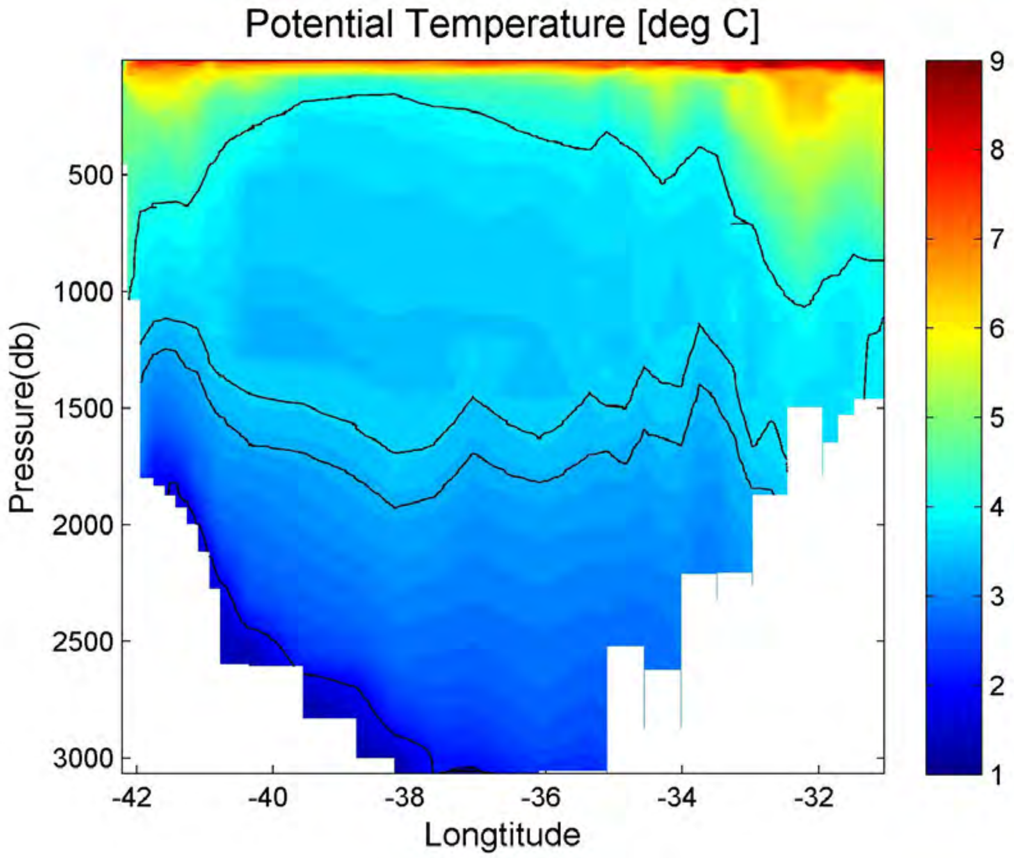


Figure 6. Potential temperature in the Irminger Sea as observed during cruise 64PE400 July 2015. Black contours mark the isopycnals 27.72, 27.7, 27.8 and 27.9 kg/m³ (from top to bottom).

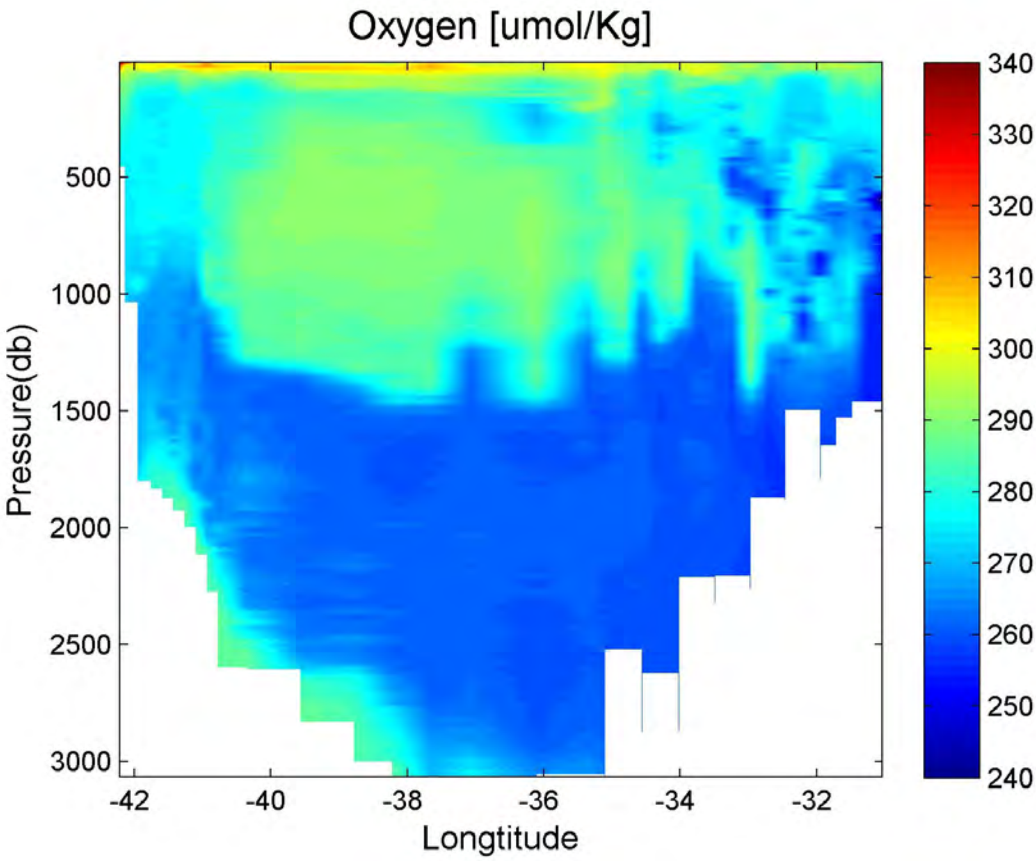


Figure 7. Dissolved oxygen in the Irminger Sea as observed during cruise 64PE400.

5.5 Data Management

All raw data were copied to a cruise directory on the network computer in different groups of sub-directories. Subsequent processed data, final products, documents and figures were copied to separate sub-directories within the cruise directory. Backups of the network disks were made on a daily basis. At the end of the cruise copies of the whole cruise directory have been made on portable hard-disk. By help of paper measurement forms and computerized data inventory files all data are tracked. A final inventory of the mooring activities, hydrographic stations, and the available raw data files was made in a cruise summary file.

6. RAFOS floats (Ryan Peabody, Duke University)

Principal Investigators: A. Bower (WHOI), S. Lozier (Duke), H. Furey (WHOI). The RAFOS deployments on board were carried out by PhD student Ryan Peabody (Duke).

Approximately 120 subsurface, acoustically tracked RAFOS floats are being released during the 2014, 2015, and 2016 OSNAP cruises to directly observe pathways of overflow waters through the subpolar North Atlantic. An array of 10 260-Hz sound sources moored during the 2014 OSNAP cruises is being used to track the floats until all the moored arrays are recovered in 2018. The positions of RAFOS floats that were deployed in the Irminger Sea on this cruise are shown in Figure 8.1.

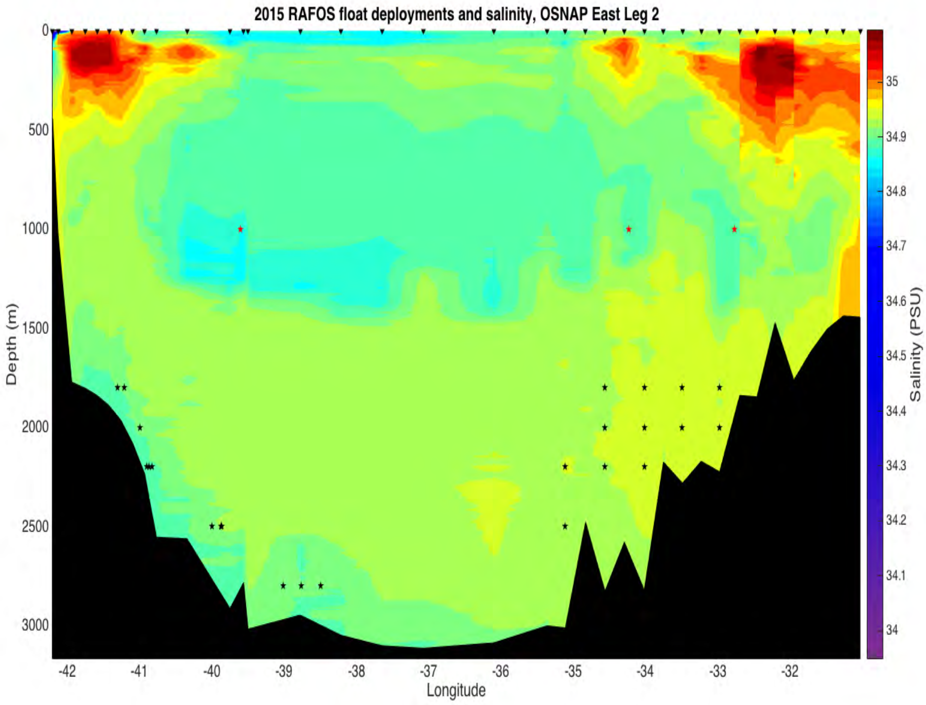


Figure 8.1: Locations of RAFOS floats deployed during 64PE400 are indicated by black stars.

6.1 The 2015 RAFOS deployments

This year's seeding was similar to last year's deployment, with one major difference: the float deployment positions in the deep Charlie-Gibbs Fracture Zone used in 2014 were moved to the OSNAP line west of the Reykjanes Ridge crest. In 2014, the ship travelled over the Charlie-Gibbs when deploying the sound source array and a one-time seeding of 10 floats was made at this location, targeting the Iceland–Scotland Overflow Water as it travels east to west through the fracture zone. The 2015 OSNAP cruises do not travel in this region, so this deployment position was re-located downstream to seed the deep mean northward flow that blankets the west Reykjanes Ridge. Also, it was unclear of any of the floats releases in the Iceland Basin or CGFZ would turn north to travel along the Irminger Sea boundary. During Year 2, a total of 47 OSNAP RAFOS deployments were planned. This increase from 40 to 47 is due to manufacturer decreasing cost of the RAFOS unit, and providing difference in the form of five additional RAFOS, and two 2014 RAFOS that were held back because they were thought to have imperfections in glass housing, but were later deemed sound.

Planned deployments for 2015 were as follows:

- Cruise 64PE399 (leg 1): 15 RAFOS on the eastern flank of the Reykjanes Ridge programmed for 730-day missions; three monitoring RAFOS floats in the Iceland Basin to give sound source information at 10, 100, and 317 days. The monitor day counts equate to: information returned in enough time to hold back deploying 2015 Leg 2 floats, in enough time to procure, ship and moor a replacement sound source, and in enough time to halt shipment on 2016 RAFOS floats.

- **Cruise 64PE400 (leg 2)**: 12 RAFOS over the western flank of the Reykjanes Ridge programmed for 730-day missions; 20 RAFOS floats over the East Greenland Slope, 17 of which were programmed for 730-day missions and 3 of which were programmed for 20 day missions;[1] and 3 monitoring RAFOS in the Irminger Basin to give sound source information at 10, 80, and 300 days, which mimics the above staggered surfacing plans.

Appendix B lists detailed deployment information for the floats on 64PE400, OSNAP East Year 2 Leg 2. Floats released on the western flank of the Reykjanes Ridge (12 total) were ballasted for 1800, 2000, 2200, and 2500 decibars. Floats released on the eastern flank of the East Greenland Slope (19 total) were ballasted for 1800, 2000, 2200, 2500, and 2800 decibars. Deployments on the Reykjanes Ridge were designed to target Iceland-Scotland Overflow Water flowing northward, while deployments on the East Greenland Slope were designed to target Denmark Strait Overflow Water flowing southward. Deployments on the Reykjanes Ridge were given a vertical structure, with 2 or 3 floats deployed at each site, ballasted for different depths. Deployments on the East Greenland Slope were clustered, with 2 or 3 floats deployed at each site, but ballasted for the same depths. Figure 8.1 shows the deployment sites superimposed on (uncalibrated) CTD salinity and Figure 8.2 shows the deployment locations over bathymetry.

1

One float was not deployed, as the wire connecting the weight to the float body was severed at some point before arrival in Iceland. This could be due to damage from transport, or a malfunction that caused an early release trigger.

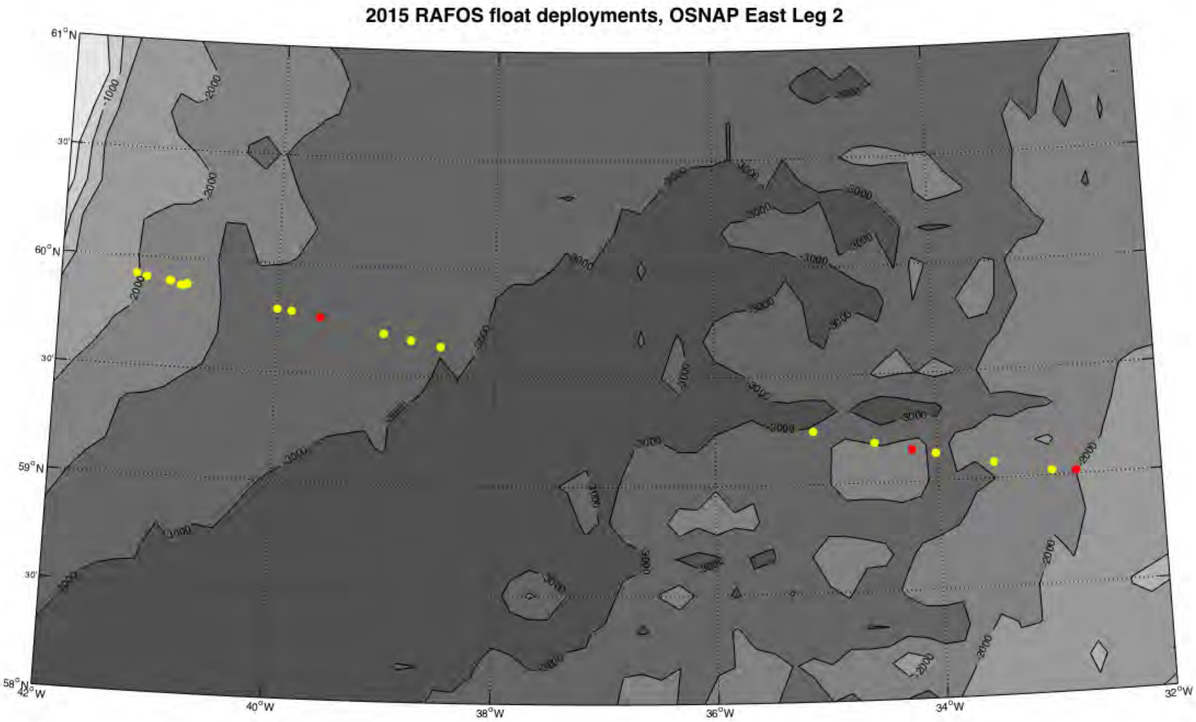


Figure 8.2: Yellow dots mark the deployment locations of the RAFOS floats during 64PE400 over bathymetry. Red dots are shallower monitoring floats.

6.2 Technical specifications and method of deployment

Two changes were made to the 2015 RAFOS float manufacturing, both changes an attempt to mitigate the effects of bottom contact, which happens on occasion when a float is pushed by current horizontally into a shallowing bottom. First, the UHDP "insulator" was retooled to remove a pocket that could potentially collect sediment, causing the float to become heavier and sink once off the bottom. Second, on half the floats, thin 2-meter lengths of plastic-coated SS wire weighing approximately 10 grams were added. This wire hangs vertically from the float bottom and will contact the seafloor first in case of bottom-brush. Because the wire is flexible, it will partially rest on the seafloor, effectively lessening the weight of the float and increasing float buoyancy. The flexible wire prevents the float itself from coming in contact with the bottom and picking up sediments. It is desirable to use a wired float for all deployments particularly close to the bottom, but this was not possible due to the limited number of wired floats (11). Wired floats were used for most 730-day deployments close to the bottom, while unwired floats were used for all 250-day deployments in the same locations. For those stations on the East Greenland Slope where multiple floats were deployed at the same location, ballasted for the same depth, and with the same mission length, at least 1 float was wired.

Most of the RAFOS floats were released using the "holey tube", ~0.25-m diameter, 2.5-m long PVC pipe. Normally this tube is used with a starch-ring piston that releases a bottom gate once the starch ring dissolves in water, an event that takes approximately 15 seconds. However, the floats were not able to be launched using this method for fear that wire would be damaged (therefore changing ballasting weight) or hang up on the PVC launcher bottom gate. Leg 1 (PE399) developed a method that was used for all deployments on Leg 2, whereby the tube is used as a simple deployment chute. The float was loaded into the tube horizontally on deck, the wire (if present) carefully unwound and fed over the ship's fantail. One person would hold the top of the glass float, while another person would edge the tube over the side, tilting both in concert at 45-60 degree angle to the water. The float and tube were then lowered as much as possible to minimize distance to water surface. Waiting for swell to come up, the float was then let go and dropped through the tube into the water. In this manner, the tail wire was not damaged, and the glass housing had no contact with the deck.

7. LADCP data collection (Laura de Steur, NIOZ)

LADCP dual head with the downward looking head provided by NOC, and the upward looking head from NIOZ. The script file with settings that was used to start the LADCP is given in **Appendix C**. On some stations (CTD stations 11 to 14) on the Reykjanes Ridge the LADCP did not work (the battery case flooded due to a bad fix of the lid after replacing the battery. All electronics were cleaned and fixed after which good data was collected again). Those stations were repeated when steaming back on to the section prior to mooring redeployments (CTD stations 19 to 21). The LADCP profiles were processed on board with LDEO software Version IX_10 (see http://www.ldeo.columbia.edu/~ant/LADCP) using 1 Hz bin-averaged CTD data (no VMADCP). The barotropic tides were removed from the profiles by using the Global 1/4°x1/4° degree tidal model TMD2.03/Model_tpox6.2:
http://www.coas.oregonstate.edu/research/po/research/tide/index.html.

8. Vessel Mounted ADCP (VMADCP) data collection (Till Bauman, GEOMAR)

A 75 kHz VMADCP (Vessel Mounted Acoustic Doppler Current Profiler), mounted downward looking in the ship's hull, is used to continuously monitor the ocean's velocity in the upper ~600m. The specifications and settings are presented in the documentation script that is attached. Although the vertical resolution of the VMADCP is substantially lower than the one from the LADCP that is attached to the CTD-rosette, its higher horizontal resolution (ø 0.5 km compared to the ø 15 km of the CTD casts) provides critical information to complement the velocity data set. While the VMADCP measured continuously during the whole cruise, we are mostly interested in the current velocities along the section between the Reykjanes ridge and Greenland. Therefore only measurements that took place along this section were considered and redundant multiple coverages of certain segments were discarded. Furthermore, to maintain a coherent spatial resolution, only data recorded during steaming (threshold = 2 m/s ~ 4 kn) is used to calculate the velocity field. In order to account for biases of the velocity readings introduced by tides, the records were detided using the Tide Model Driver (TMD) and the associated global 1/4° tide model6.2. The removed tidal biases have peak amplitudes of 0.05 m/s and are assumed to act barotropically on the water masses within depth range covered by the VMADCP. In the next step the velocity field is rotated by 10° clockwise so that the U and V components refer to along-section and cross-section instead of the original east and north component, respectively. The rotated data is then interpolated on an equidistant grid (0.1° by 10 m) using elliptic gaussian weights with influence and cut-off radii of 0.2° by 20 m and 0.5° by 70 m, respectively.

The results are depicted in Figure 9.1. The high barotropicity of the velocity signals over the top 600 m allows for a vertically averaged display of the currents in the context of topography: In Figure 9.2, the cruise track (green), the position of the data actually used (red) and the vertically averaged VMADCP velocities (arrows) are shown. The dominant feature of this section is the northward flow along the Reykjanes ridge in the East and the Southward flow of the Irminger Current along the Greenland shelf in the West. Interestingly there are quite pronounced velocity signals in the central Irminger Sea as well. Since they are located above the deepest part of the basin, the full-depth LADCP casts might help to explain these currents.

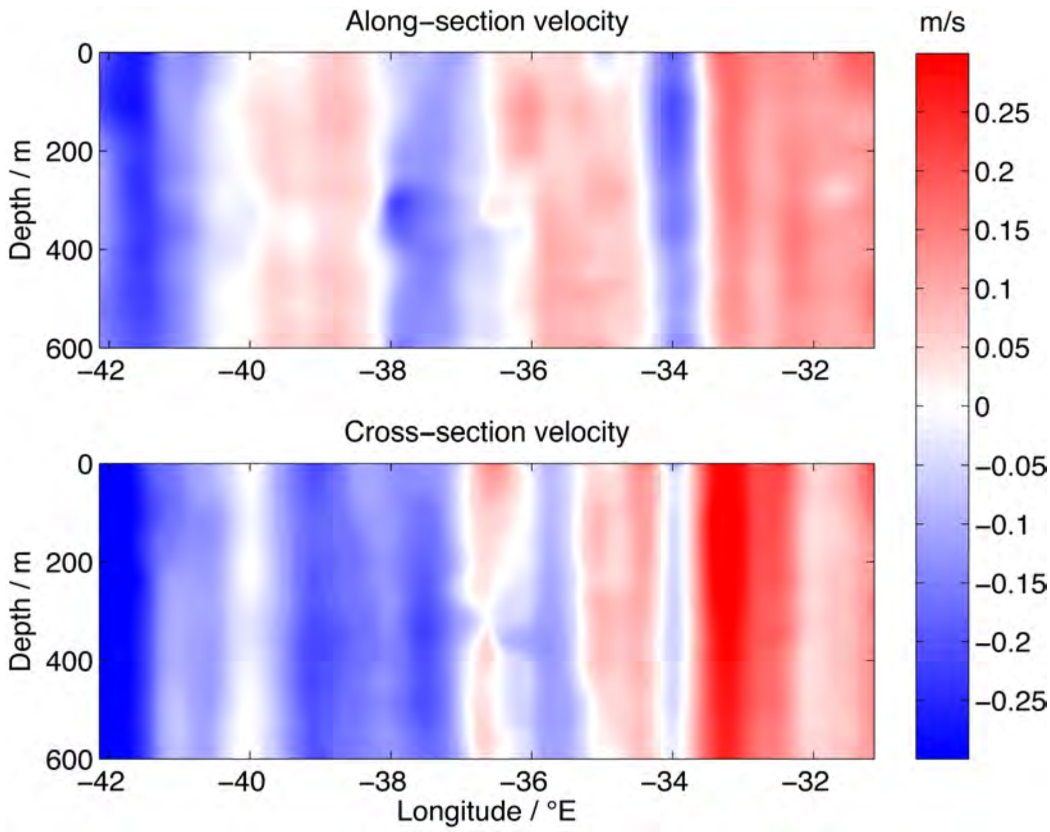


Figure 9.1: Along and across-section velocity as obtained by the VMADCP.

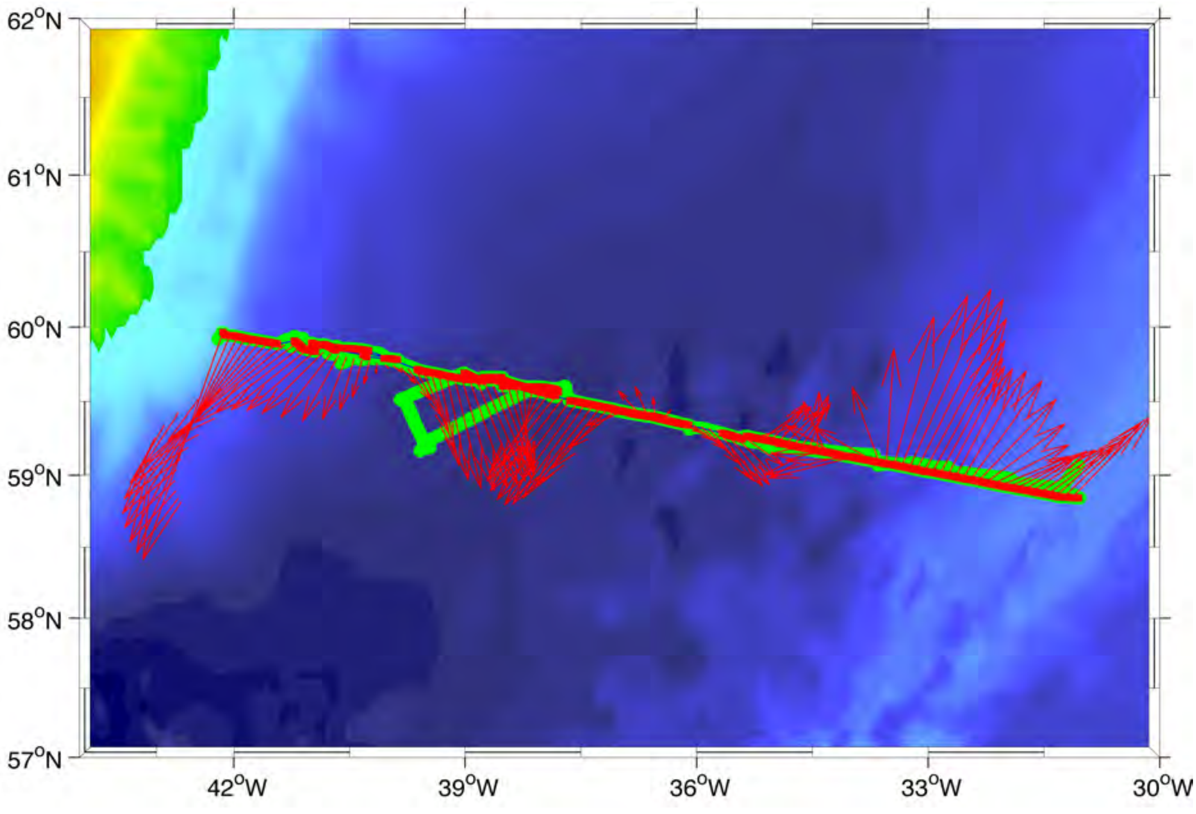


Figure 9.2: Vector plot of the (600 m) depth-averaged velocity obtained from the VMADCP on the main section.

9. Outreach

During the cruise (bi-) weekly updates with 1.5 min short film clips were send to the OSNAP cruise blog: http://www.o-snap.org/category/cruises/

In addition, a 10-minute long short film "Go With the flow of the North Atlantic Ocean" was made to illustrate the background and relevance of the two large projects that this cruise supports and to show how the oceanographic fieldwork is carried out. The filming and first cut of the film was done by Maarten Roos on board (CurveLight-Films, NL). The animations and post production of the film were done by Dick Peterse and Dan Brinkhuis (Science Media). The film was shown at the AGU General Assembly in San Francisco in December 2015, and the EGU General Assembly in Vienna in April 2016. The film is posted on the following NIOZ Youtube Channel:
https://www.youtube.com/watch?v=a-lhCIQjE4c

Acknowledgments

The Dutch contribution to OSNAP has received funding from the European Union 7th Framework Programme (FP7 2007-2013), under grant agreement n.308299 (NACLIM www.naclim.eu). The Royal Netherlands Institute for Sea Research NIOZ (NWO) subsidized 20 days of ship time to the OSNAP program. In addition, a large part of the moored instrumentation (ADCPs, RCMs, Aquadopps, releases, and beacons, as well as some SBE37 Microcats) were provided by the Marine Research Facilities (MRF) pool from NIOZ as an in-kind contribution to the project.

Appendix A: List of CTD stations

Nr, Date Time, Deg/Min North, Deg/Min West, Decimal Deg. North, Decimal Deg. West

01, Jul 11 2015 16:48:08, 59 14.60°N, 35 06.76°W, 59.2433°N, 35.1127°W

02, Jul 11 2015 21:03:30, 59 16.08°N, 35 21.88°W, 59.2680°N, 35.3647°W

03, Jul 12 2015 02:05:51, 59 12.61°N, 34 49.96°W, 59.2102°N, 34.8327°W

04, Jul 12 2015 05:44:23, 59 10.98°N, 34 33.87°W, 59.1830°N, 34.5645°W

05, Jul 12 2015 09:16:51, 59 09.34°N, 34 17.75°W, 59.1557°N, 34.2958°W

06, Jul 12 2015 12:45:55, 59 07.64°N, 34 01.21°W, 59.1273°N, 34.0202°W

07, Jul 12 2015 16:21:40, 59 06.04°N, 33 45.33°W, 59.1007°N, 33.7555°W

08, Jul 12 2015 19:29:52, 59 04.46°N, 33 29.52°W, 59.0743°N, 33.4920°W

09, Jul 12 2015 22:37:02, 59 02.85°N, 33 14.02°W, 59.0475°N, 33.2337°W

10, Jul 13 2015 01:58:45, 59 01.38°N, 32 58.64°W, 59.0230°N, 32.9773°W

11, Jul 13 2015 05:11:46, 58 59.66°N, 32 42.15°W, 58.9943°N, 32.7025°W

12, Jul 13 2015 07:47:18, 58 58.22°N, 32 27.95°W, 58.9703°N, 32.4658°W

13, Jul 13 2015 10:40:40, 58 56.67°N, 32 12.60°W, 58.9445°N, 32.2100°W

14, Jul 13 2015 13:00:07, 58 55.00°N, 31 57.03°W, 58.9167°N, 31.9505°W

15, Jul 13 2015 15:48:43, 58 53.67°N, 31 43.31°W, 58.8945°N, 31.7218°W

16, Jul 13 2015 18:26:58, 58 52.32°N, 31 29.66°W, 58.8720°N, 31.4943°W

17, Jul 13 2015 20:42:42, 58 50.93°N, 31 15.94°W, 58.8488°N, 31.2657°W

18, Jul 13 2015 22:57:36, 58 50.52°N, 31 02.07°W, 58.8420°N, 31.0345°W

19, Jul 14 2015 13:34:53, 58 55.00°N, 31 57.03°W, 58.9167°N, 31.9505°W

20, Jul 14 2015 18:49:04, 58 56.70°N, 32 12.54°W, 58.9450°N, 32.2090°W

21, Jul 14 2015 21:05:47, 58 58.21°N, 32 27.93°W, 58.9702°N, 32.4655°W

22, Jul 14 2015 23:28:40, 58 59.69°N, 32 42.13°W, 58.9948°N, 32.7022°W

23, Jul 16 2015 08:08:57, 59 20.54°N, 36 06.21°W, 59.3423°N, 36.1035°W

24, Jul 16 2015 14:07:07, 59 26.74°N, 37 04.43°W, 59.4457°N, 37.0738°W

25, Jul 16 2015 19:00:28, 59 30.50°N, 37 39.08°W, 59.5083°N, 37.6513°W

26, Jul 17 2015 19:10:26, 59 37.76°N, 38 46.91°W, 59.6293°N, 38.7818°W

27, Jul 18 2015 19:40:35, 59 12.06°N, 39 30.21°W, 59.2010°N, 39.5035°W

28, Jul 19 2015 00:55:42, 59 28.73°N, 39 45.23°W, 59.4788°N, 39.7538°W

29, Jul 19 2015 08:35:56, 59 12.05°N, 39 30.25°W, 59.2008°N, 39.5042°W

30, Jul 19 2015 23:40:21, 59 34.10°N, 38 13.05°W, 59.5683°N, 38.2175°W

31, Jul 20 2015 22:07:48, 59 42.31°N, 39 33.94°W, 59.7052°N, 39.5657°W

32, Jul 21 2015 16:20:06, 59 49.34°N, 40 46.35°W, 59.8223°N, 40.7725°W

33, Jul 22 2015 07:34:19, 59 46.89°N, 40 20.93°W, 59.7815°N, 40.3488°W

34, Jul 23 2015 11:22:44, 59 50.31°N, 40 56.12°W, 59.8385°N, 40.9353°W

35, Jul 23 2015 14:24:12, 59 51.24°N, 41 05.91°W, 59.8540°N, 41.0985°W

36, Jul 23 2015 17:50:32, 59 52.21°N, 41 15.74°W, 59.8702°N, 41.2623°W

37, Jul 23 2015 21:02:24, 59 53.18°N, 41 25.56°W, 59.8863°N, 41.4260°W

38, Jul 23 2015 23:30:06, 59 54.09°N, 41 35.36°W, 59.9015°N, 41.5893°W

39, Jul 24 2015 02:05:51, 59 55.02°N, 41 45.19°W, 59.9170°N, 41.7532°W

40, Jul 24 2015 04:42:04, 59 56.13°N, 41 56.63°W, 59.9355°N, 41.9438°W

41, Jul 24 2015 07:48:41, 59 57.26°N, 42 08.10°W, 59.9543°N, 42.1350°W

42, Jul 24 2015 11:16:55, 59 54.91°N, 42 12.46°W, 59.9152°N, 42.2077°W

43, Jul 26 2015 06:42:15, 64 21.43°N, 35 03.62°W, 64.3572°N, 35.0603°W

44, Jul 26 2015 08:45:45, 64 23.81°N, 35 08.68°W, 64.3968°N, 35.1447°W

45, Jul 26 2015 10:09:35, 64 24.96°N, 35 11.03°W, 64.4160°N, 35.1838°W

46, Jul 26 2015 11:58:01, 64 31.39°N, 35 24.64°W, 64.5232°N, 35.4107°W

47, Jul 26 2015 13:24:12, 64 35.13°N, 35 32.52°W, 64.5855°N, 35.5420°W

48, Jul 26 2015 17:22:57, 64 11.81°N, 34 43.71°W, 64.1968°N, 34.7285°W

49, Jul 26 2015 19:54:46, 64 06.28°N, 34 32.43°W, 64.1047°N, 34.5405°W

50, Jul 26 2015 22:47:21, 63 59.79°N, 34 19.79°W, 63.9965°N, 34.3298°W

51, Jul 27 2015 02:00:45, 63 51.05°N, 34 00.85°W, 63.8508°N, 34.0142°W

Appendix B: List of RAFOS float deployments 2015 (leg 2)

	Serial Number	Ballast / Target Depth (m)	Wired float	Mission (days)	Deployment Date	Deployment Time (GMT)	Decimal Latitude (°N)	Decimal Longitude (°W)	Water depth (m)	Iridium IMEI Number
Monitor	1045	1000	N	8	20150710	17:50:53	59.0150	32.7705	1999	300234010115360
	1131	1000	N	80	20150715	17:33:07	59.1469	34.2360	2417	300234010139170
	1117	1000	N	300	20150722	14:12:27	59.7567	39.6063	2668	300234011477240
Reykjanes Ridge	1385	2500	N	730	20150711	19:25:30	59.2433	35.1133	3019	300234062920640
	1380	2200	N	730	20150711	19:26:46	59.2434	35.1132	3018	300234062922640
	1372	2200	Y	730	20150712	8:05:28	59.1827	34.5634	2851	300234062618940
	1368	2000	N	730	20150712	8:06:34	59.1828	34.5631	2852	300234062613940
	1363	1800	N	730	20150712	8:07:21	59.1830	34.5629	2895	300234062614940
	1371	2200	Y	730	20150712	15:10:52	59.1276	34.0196	2847	300234062619930
	1367	2200	N	730	20150712	15:11:27	59.1276	34.0196	2843	300234062610950
	1362	1800	N	730	20150712	15:12:26	59.1277	34.0196	2845	300234062618930
	1361	2000	Y	730	20150712	21:27:55	59.0746	33.4936	2309	300234062613950
	1353	1800	N	730	20150712	21:28:40	59.0747	33.4939	2309	300234061822340
	1364	2000	Y	730	20150713	3:55:21	59.0232	32.9776	2252	300234062614910
	1352	1800	N	730	20150713	3:56:22	59.0230	32.9775	2251	300234061823360
East Gr	1389	280	N	730	20150717	13:28:42	59.6398	38.4988	4867	300234062924640

		0								
	1392	2800	N	730	20150717	13:30:36	59.6398	38.4995	4141	300234062928640
	1394	2800	Y	730	20150717	16:59:52	59.6648	38.7661	2969	300234062921640
	1393	2800	N	250	20150717	17:01:20	59.6650	38.7658	2969	300234062927630
	1395	2800	Y	250	20150717	23:08:08	59.6924	39.0167	2916	300234062610930
	1388	2500	N	730	20150721	22:10:52	59.7828	39.8733	2705	300234062925640
	1387	2500	N	730	20150721	22:11:56	59.7827	39.8739	2705	300234062920650
	1386	2500	N	250	20150721	22:45:42	59.7895	39.9993	2678	300234062923650
	1391	2500	Y	730	20150721	22:46:42	59.7895	39.9996	2678	300234062922650
	1390	2500	Y	730	20150721	22:47:44	59.7896	39.9998	2678	300234062928630
ee nla nd	1384	2200	N	730	20150722	18:50:52	59.8838	40.8340	2480*	300234062926650
	1375	2200	Y	730	20150722	18:51:45	59.8839	40.8340	2480*	300234062929610
	1381	2200	N	730	20150722	19:09:03	59.8808	40.8724	2416	300234062923640
	1382	2200	N	730	20150722	19:09:48	59.8807	40.8724	2416	300234062617930
	1383	2200	Y	730	20150722	19:21:14	59.8763	40.9008	2310	300234062929640
	1376	2000	N	730	20150722	19:46:06	59.8937	40.9967	2222	300234062924650
	1377	2000	N	730	20150722	19:46:53	59.8937	40.9968	2222	300234062921650
	1337	1800	N	250	20150723	17:21:59	59.9093	41.2196	2022	300234061824860
	1350	1800	Y	730	20150723	20:23:53	59.9192	41.3113	1975	300234061829340
	1348	1800	N	250	Not deployed due to malfunction					300234061820870

** Station depths for floats 1384 and 1375 were not recorded in the Casino database. Depths taken by hand at time of deployment were used instead.*

Appendix C: LADCP script files

Master:	Slave:
CR1 WM15 EA0 EB0 ED0 ES35 EX11111 EZ0111111 CB411 CF11111 RNM051_ SW75 SM1 SA001 TE00:00:01.00 TP00:01.00 SI0 WB0 WD111100000 WF176 WP1 WN15 WS800 WV175 LZ030,220 CK CS	CR1 WM15 EA0 EB0 ED0 ES35 EX11111 CB411 CF11111 RNS051_ EZ0111111 SM2 SA001 ST300 TE00:00:00.00 TP00:00.00 WB0 WD111100000 WP1 WN15 WS800 WF176 WV175 LZ030,220 CK CS

Appendix D: NOC CTD processing in relation to calibration dip

Stage 0

The CTD data processing used the mstar software suite (also know as mexec), developed at NOC. The initial Seabird data conversion, align[2] and cell thermal mass[3] were performed using SBE Data Processing, Version 7.21d software. The processed CTD data were copied automatically on a shared network drive (Portus) through the execution of a seabird batch file. The network data drive, Portus, was linked to the */home/mstar/cruise/data/shipfs* and the ctd folder was linked to *~/cruise/data/ctd/ASCII_files/shipfs_ctd* . The script *ctd_linkscript_pe400* is executed in a tcsh shell to copy files from the network drive to the mstar computer and set up additional symbolic links to filenames following mstar convention.

2 Set to 5s only for the data from the SBE43 sensor (oxygen sensor)

3 Thermal anomaly amplitude (alpha) set to 0.03 and thermal anomaly time constant (tau) set to 7.0, according to Seabird recommendations

Stage 1

The first step of the processing is the creation of empty sample files *sam_pe400_nnn.nc* for all casts *nnn*. These files were generated from the list of variables indicated in the file *~/cruise/data/templates/sam_pe400_varlist.csv* through the execution of the scripts *msam_01*, *msam_01b* (as described in the comments at the beginning of *msam_01b*).

For each cast the following matlab files were run, using a wrapper *script ctd_all_part1*: *mctd_01*, *mctd_02a*, *mctd_02b*, *mctd_03*, *msam_putpos*, *mdcs_01*, *mdcs_02*.

The processes completed by these scripts include:

- read ASCII cnv data from *data/ctd/ASCII_FILES/ctd_pe400_nnn_ctm.cnv;*
- convert variable names from SBE names to mstar names using *data/templates/ctd_pe400_renamelist.csv*
- convert raw file to 24hz file
- make oxygen hysteresis ajustement on 24hz file
- average to 1hz
- calculate derived variables psal et potemp
- extract information from the ship navigation data for the bottom of cast identified by maximum pressure

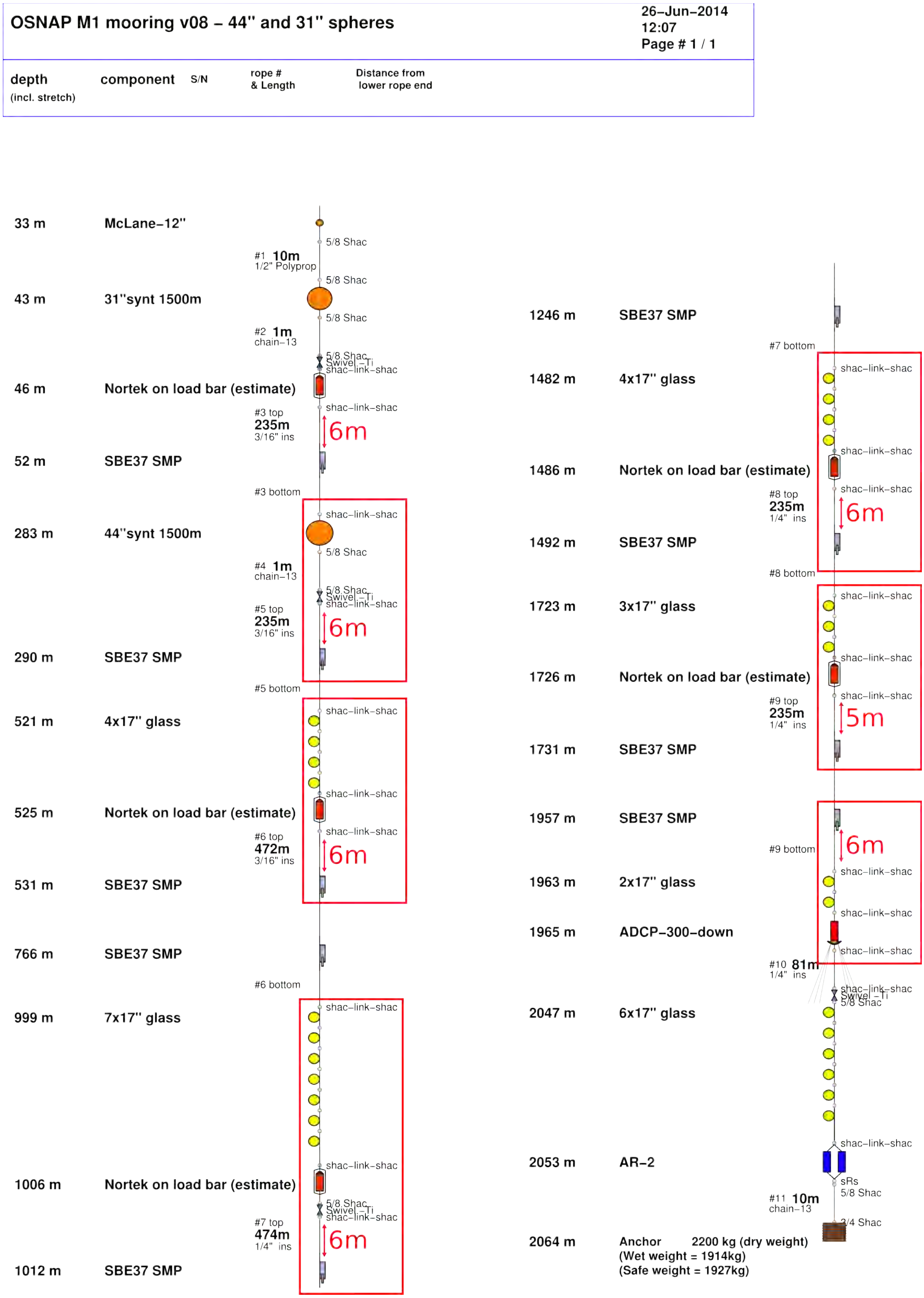
Stage 2

Then the script *mdcs_03g_pe400* was run to inspect profiles and hand-select cast start and end times. The start, bottom and end data cycles are stored for each cast *nnn* in files *dcs_pe400_nnn.nc*. After selecting the limits for start and end, *ctd_all_part2_pe400* was then run, executing *mctd_04_pe400*, *mfir_01*, *mfir_02*, *mfir_03*, *mfir_04*, *mbot_00*, *mbot_01*, *mbot_02*. The processes completed by these scripts include:

- extract down and upcasts using scan numbers stored in *dcs_pe400_nnn.nc*, and average into 2dbar files (2db down and 2db up)
- read the *data/ctd/ASCII_FILES/ctd_pe400_001.bl* file and extract scan numbers corresponding to bottle firing events.
- add time from CTD file, merging on scan number
- add CTD upcast data corresponding to bottle firing events
- paste these data into master sample file *data/ctd/sam_pe400_nnn.nc*
- paste the bottle firing codes and quality flag into the master sample file

When a conductivity calibration is available, it is applied to the 24hz files using *mctd_condcal*. Then a subset of scripts can be rerun, specifically *mctd_02b*, *mctd_condcal*, *mctd_03*, *mctd_04_pe400*, *mfir_03*, *mfir_04*. This collection of calls can be run through the script *smallscript_pe399.*

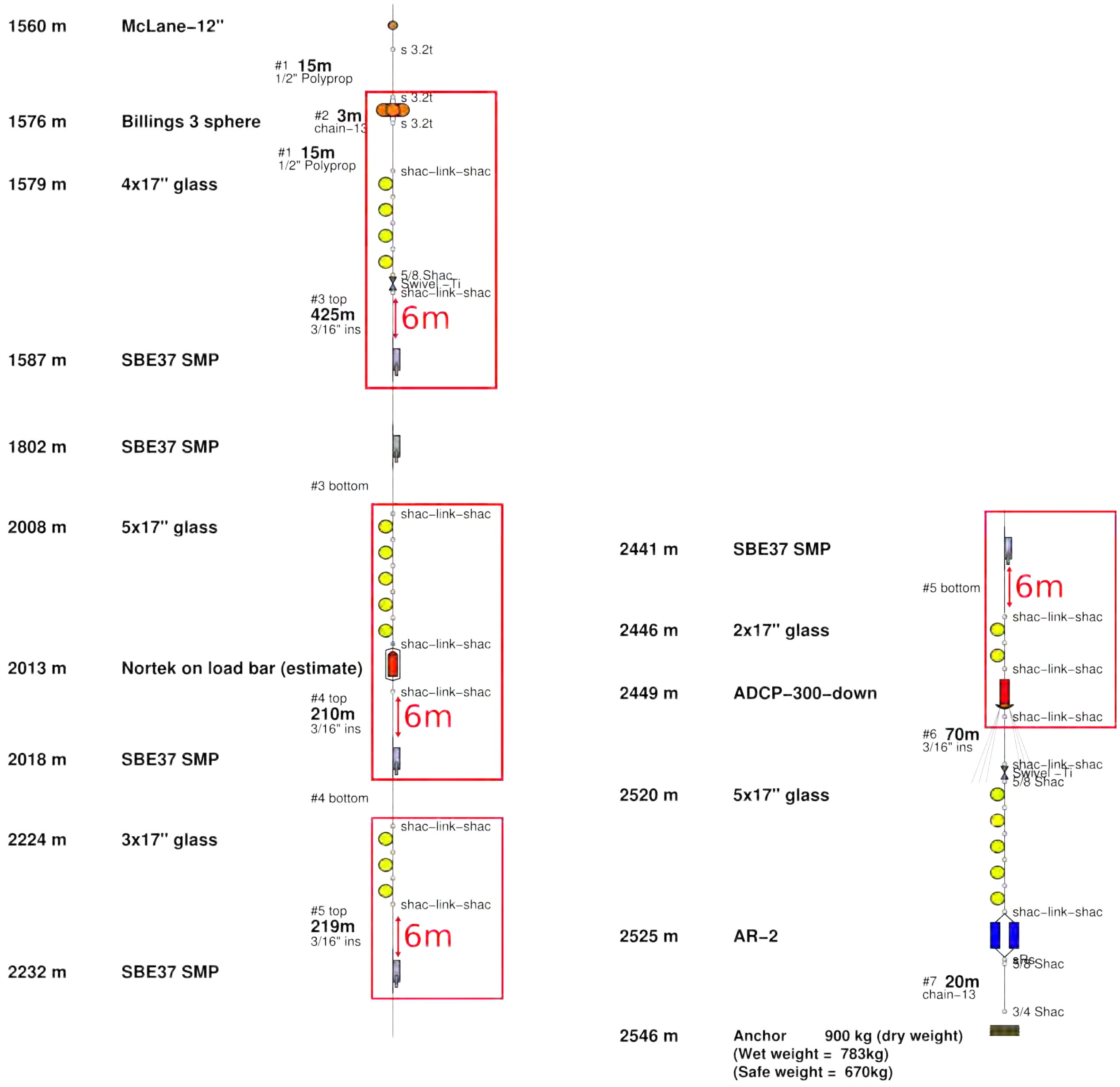
Appendix E: NOC Mooring designs M1-M5 deployed

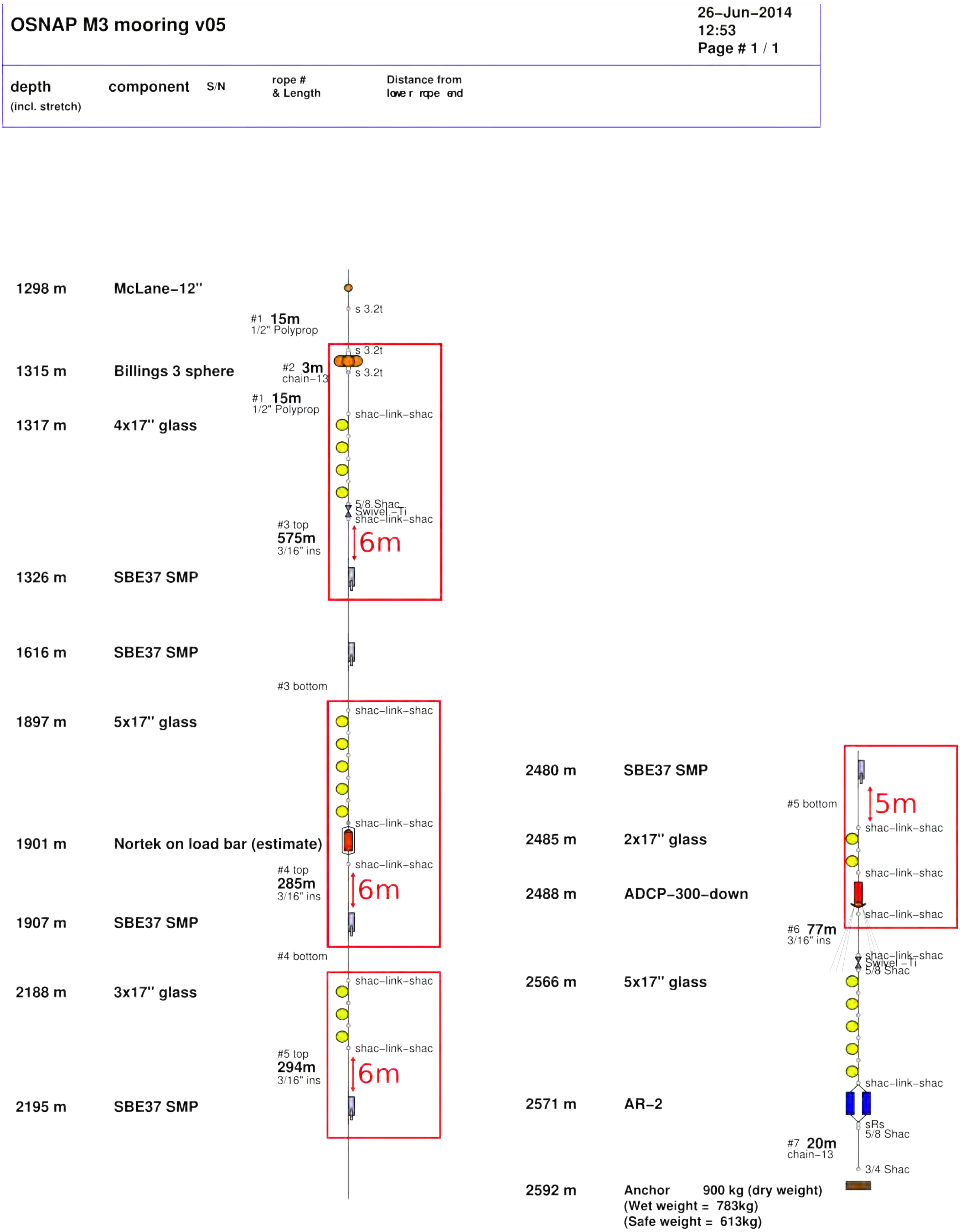


OSNAP M2 mooring v07

26–Jun–2014
11:57
Page # 1 / 1

depth (incl. stretch) | component | S/N | rope # & Length | Distance from lower rope end

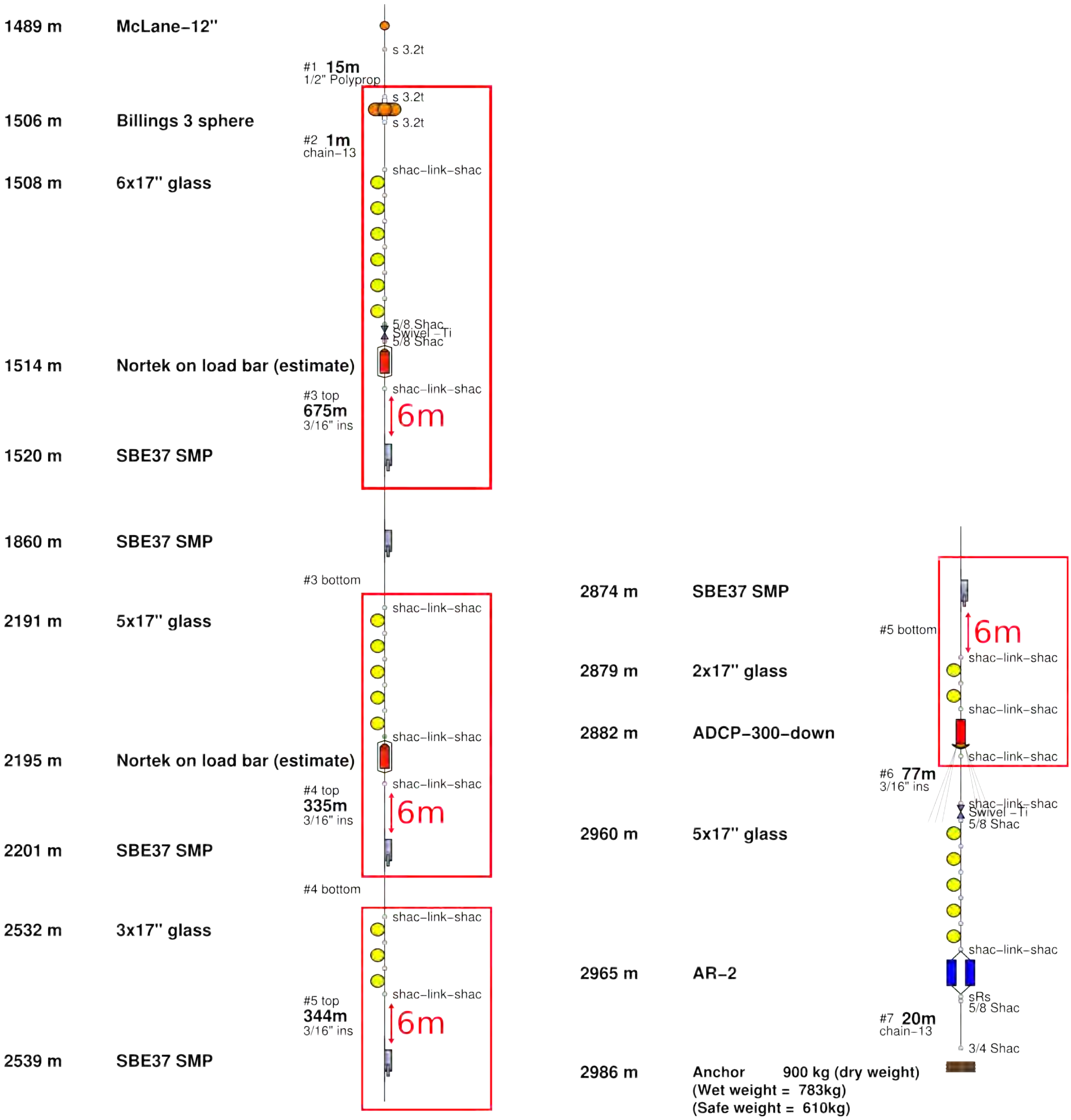



OSNAP M3 mooring v05
26–Jun–2014
12:53
Page # 1 / 1
depth
(incl. stretch)
component
S/N
rope #
& Length
Distance from
lower rope end
1298 m McLane–12"
#1 15m
1/2" Polyprop
s 3.2t
s 3.2t
1315 m Billings 3 sphere
#2 3m
chain–13
s 3.2t
#1 15m
1/2" Polyprop
shac–link–shac
1317 m 4x17" glass
5/8 Shac
Swivel –Ti
shac–link–shac
#3 top
575m
3/16" ins
6m
1326 m SBE37 SMP
1616 m SBE37 SMP
#3 bottom
shac–link–shac
1897 m 5x17" glass
shac–link–shac
1901 m Nortek on load bar (estimate)
shac–link–shac
#4 top
285m
3/16" ins
6m
1907 m SBE37 SMP
#4 bottom
shac–link–shac
2188 m 3x17" glass
shac–link–shac
#5 top
294m
3/16" ins
6m
2195 m SBE37 SMP
2480 m SBE37 SMP
#5 bottom
5m
shac–link–shac
2485 m 2x17" glass
shac–link–shac
2488 m ADCP–300–down
shac–link–shac
#6 77m
3/16" ins
shac–link–shac
Swivel –Ti
5/8 Shac
2566 m 5x17" glass
shac–link–shac
2571 m AR–2
sRs
5/8 Shac
#7 20m
chain–13
3/4 Shac
2592 m Anchor 900 kg (dry weight)
(Wet weight = 783kg)
(Safe weight = 613kg)

OSNAP M4 mooring v05

27–Jun–2014
17:40
Page #1 / 1

depth (incl. stretch)	component	S/N	rope # & Length	Distance from lower rope end



OSNAP M5 mooring v05

27–Jun–2014
17:46
Page # 1 /1

depth (incl. stretch) | component | S/N | rope # & Length | Distance from lower rope end

1555 m McLane–12"

1571 m Billings 3 sphere

1574 m 6x17" glass

1584 m SBE37 SMP

1945 m SBE37 SMP

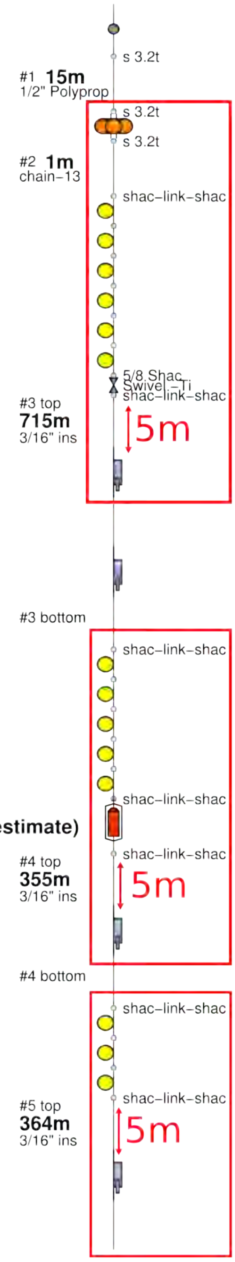
2296 m 5x17" glass

2300 m Nortek on load bar (estimate)

2306 m SBE37 SMP

2657 m 3x17" glass

2664 m SBE37 SMP



3019 m SBE37 SMP

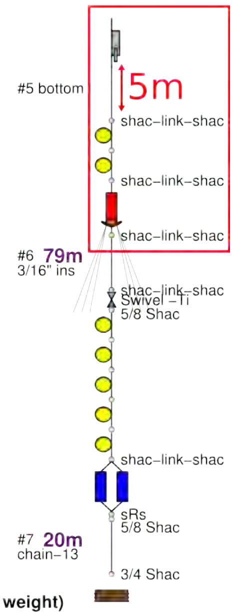
3024 m 2x17" glass

3026 m ADCP–300–down

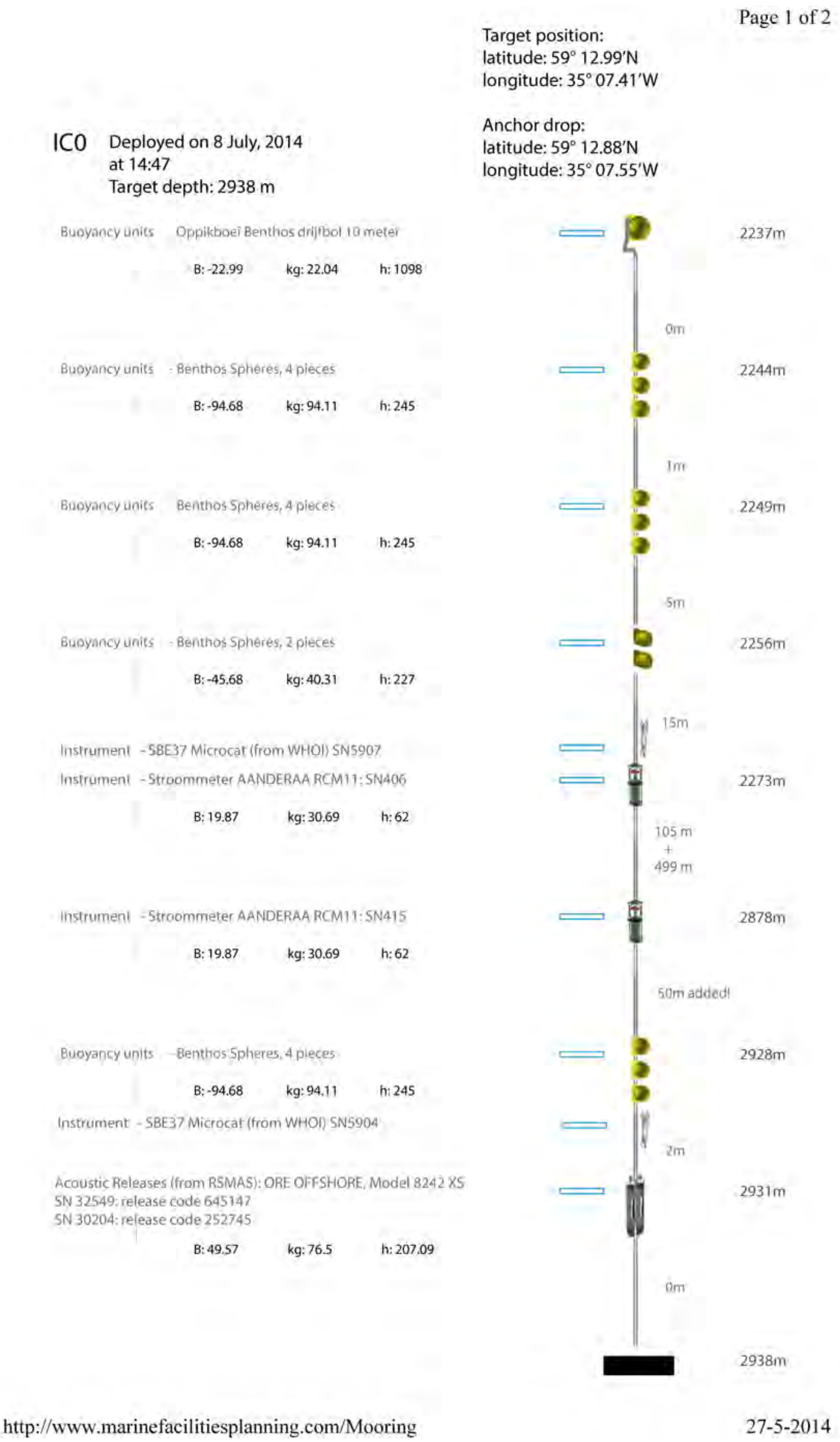
3107 m 5x17" glass

3112 m AR–2

3133 m Anchor 900 kg (dry weight)
(Wet weight = 783kg)
(Safe weight = 574kg)



Appendix F: NIOZ Mooring designs IC0-IC4



Deployed 9 July 2014
at 17:33
Target depth: 2500 m
Depth at anchor drop: 2509 m

Target position:
latitude: 59° 06.26'N
longitude: 33° 41.125'W

Anchor drop:
latitude: 59° 05.93'N
longitude: 33° 40.93'N

IC1

Buoyancy units - Oppikboei Benthos drijfbol 10 meter

B: -22.99 kg: 22.04 h: 1098

Buoyancy units - Benthos Spheres, 2 pieces

B: -45.68 kg: 40.31 h: 227

Instrument - MicroCat SBE 37-SMP SN 12046

B: 2.2 kg: 3.7 h: 0

Instrument - Thermistor SBE 56 SN 3946

Instrument - Dyneema 400 meter

B: 0.69 kg: 25.91 h: 4019

Instrument - MicroCat SBE 37-SMP SN 12047
B: 2.2 kg: 3.7 h: 0
Beacon - XEOS sn 30003401 3902100
Buoyancy units - CRP 1500/500 Type A + ADCP 1500 (UL) SN 3514

B: -420.29 kg: 636.07 h: 647

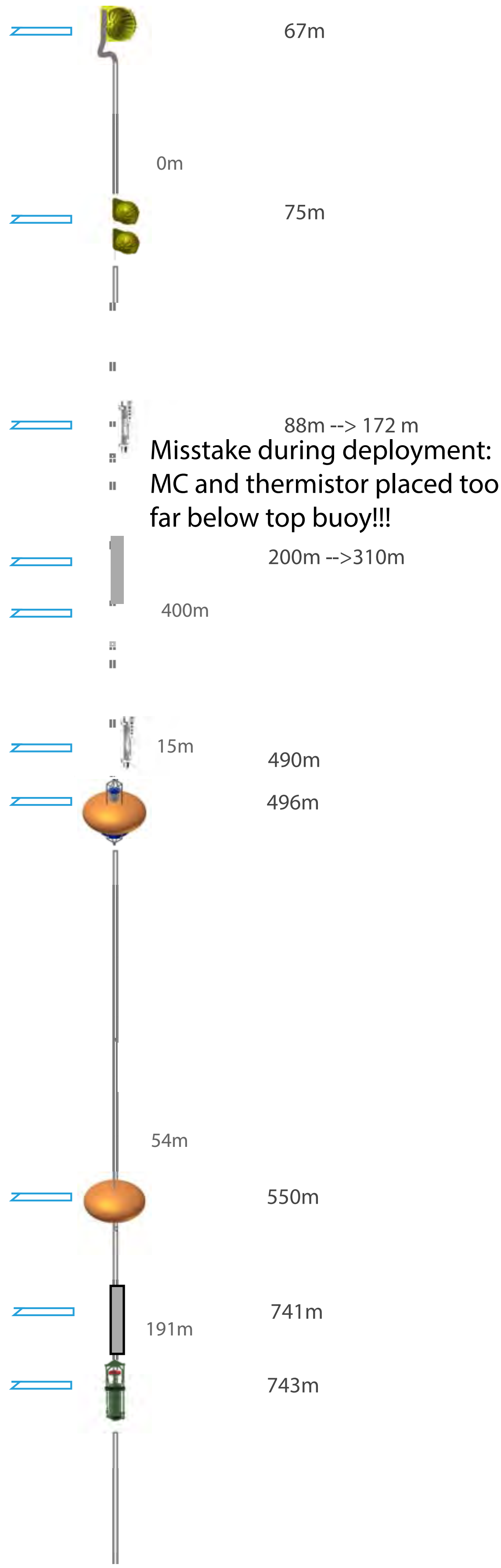
Buoyancy units - CRP 1500/100 Type C

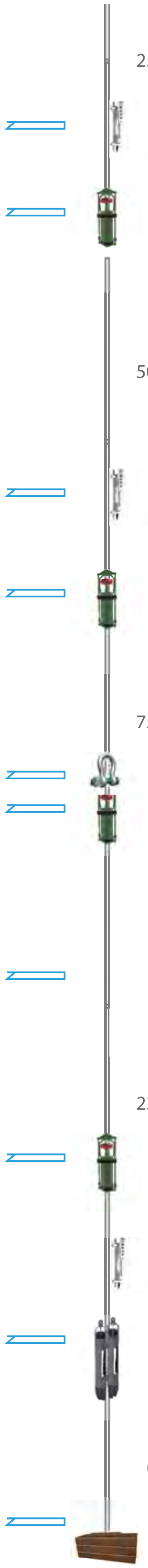
B: -85.09 kg: 117.07 h: 577

Instrument - Thermistor SBE 56 SN 3945

Instrument - Stroommeter Nortek Aquadopp SN P20126-2

B: 19.87 kg: 30.69 h: 62





251m

Instrument - MicroCat SBE 37-SMP SN 12048 — 994m

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter Nortek Aquadopp SN P286-6/02 — 996m

B: 19.87 kg: 30.69 h: 62

501m

Instrument - MicroCat SBE 37-SMP SN 12049 — 1497m

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter Nortek Aquadopp SN P20126-4 — 1499m

B: 19.87 kg: 30.69 h: 62

752m

Instrument - Sluiting GPH 1.5ton+ Splitpen

Instrument - Stroommeter Nortek Aquadopp SN P286-7/02 — 2251m

231m

Instrument - Stroommeter Nortek Aquadopp SN P286-8/02 — 2482m

B: 19.87 kg: 30.69 h: 62

Added 20 m extra!

Instrument - MicroCat SBE 37-SMP SN 12050 — 2500m

B: 2.2 kg: 3.7 h: 0

Releases - Acoustic Release, IXSEA AR861 B2S — 2502 m

B: 49.57 kg: 76.5 h: 207.09

SN 170 ARM 04DA Release code: ARM+0455
SN 147 ARM 04C2 Release code: ARM+55

0m

Anker - Ankergewicht (700 kg) — 2509 m

Remains on the seabed

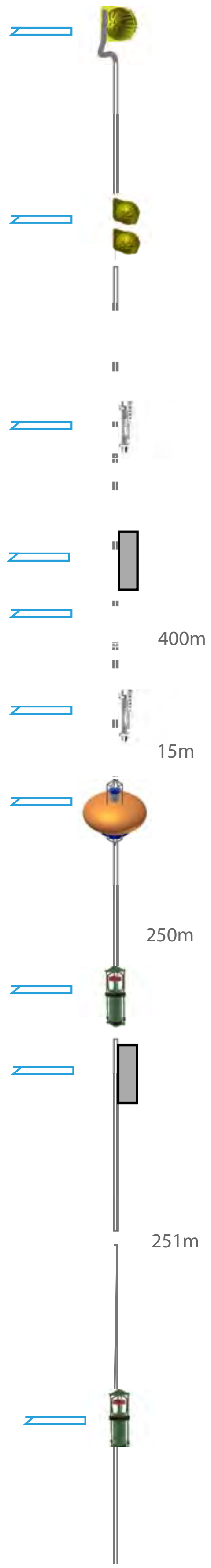
B: 710.22 kg: 814.56 h: 558

IC2

Deployed 10 July 2014
at 10:17 UTC
Target depth: 1978 m

Target position:
latitude: 59° 01.40′N
longitude: 32° 45.63′W

Anchor drop:
latitude: 59° 01.23′N
longitude: 32° 46.05′W



Buoyancy units - Oppikboei Benthos drijfbol 10 meter — 48 m

B: -22.99 kg: 22.04 h: 1098

Buoyancy units - Benthos Spheres, 2 pieces — 55 m

B: -45.68 kg: 40.31 h: 227

Instrument - MicroCat SBE 37-SMP SN 12060 — 60 m

B: 2.2 kg: 3.7 h: 0

Instrument - Thermistor SBE56 SN 3949 — 200 m

Instrument - Dyneema 400 meter +

B: 0.69 kg: 25.91 h: 40019

Instrument - MicroCat SBE 37-SMP SN12058 — 455 m

B: 2.2 kg: 3.7 h: 0

Beacon - XEOS sn 30003401 3708960

Buoyancy units - CRP 1500/500 Type A + ADCP 1500 (UL) SN 3439 — 470 m

B: -420.29 kg: 636.07 h: 647

Instrument - Stroommeter AANDERAA RCM11 SN 408 — 721 m

B: 19.87 kg: 30.69 h: 62

Instrument Thermistor SBE56 SN 3950 — 723 m

Instrument - Stroommeter AANDERAA RCM11 SN 48 — 972 m

B: 19.87 kg: 30.69 h: 62

Instrument - MicroCat SBE 37-SMP SN 12059

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter AANDERAA RCM11 SN 206

B: 19.87 kg: 30.69 h: 62

Instrument - MicroCat SBE 37-SMP SN 12056

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter AANDERAA RCM11 SN 203

B: 19.87 kg: 30.69 h: 62

Instrument - Stroommeter AANDERAA RCM11 SN 132

B: 19.87 kg: 30.69 h: 62

Instrument - MicroCat SBE 37-SMP 12057

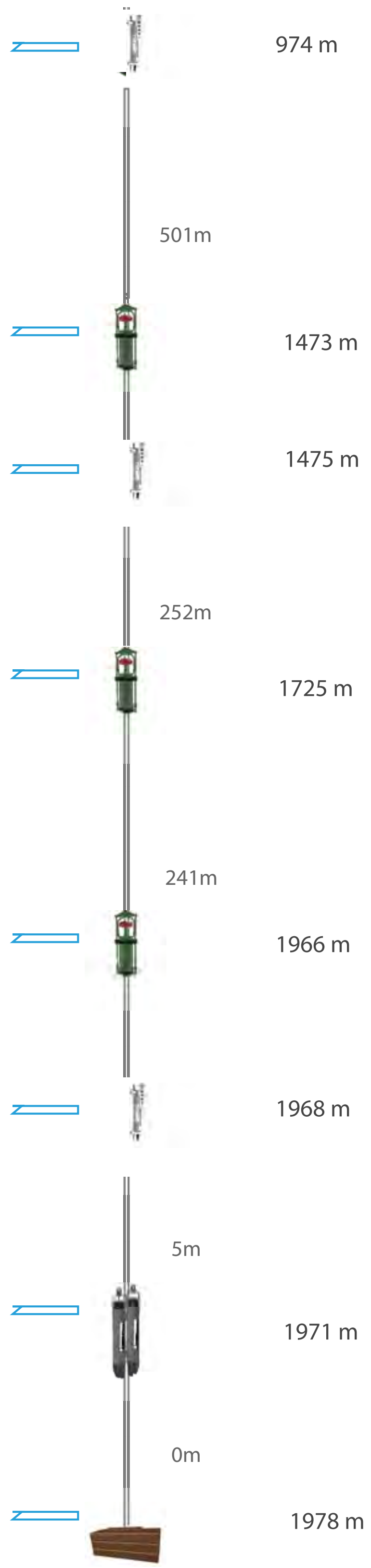
B: 2.2 kg: 3.7 h: 0

Releases Acoustic Release, IXSEA AR861 B2S
SN 1394 ARM 0971 (release ARM+0955)
SN 450 ARM 1478 (release ARM+ 55)
B: 49.57 kg: 76.5 h: 207.09

Anker - Ankergewicht (600 kg)

Remains on the seabed

B: 610.22 kg: 699.56 h: 558

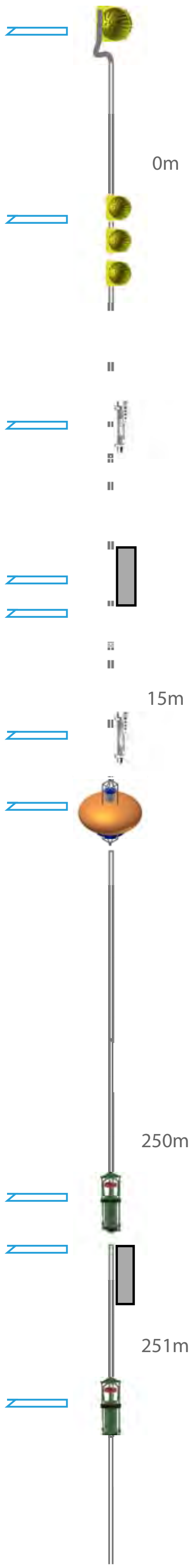


Target position:
latitude: 58° 57.35′N
longitude: 31° 57.17′W

Anchor drop:
latitude: 58° 57.33′N
longitude: 31° 57.54′W

IC3

Deployed on July 10, 2014
at 14:58 UTC
Target depth: 1635 m



Buoyancy units - Oppikboei Benthos drijfbol 10 meter — 48m

B: -22.99 kg: 22.04 h: 1098

Buoyancy units - Benthos Spheres, 3 pieces — 58m

B: -70.98 kg: 57.61 h: 227

Instrument - MicroCat SBE 37-SMP SN 12052 — 63m

B: 2.2 kg: 3.7 h: 0

Instrument - Thermistor SBE56 SN 3947 — 190m

Instrument - Dyneema 400 meter +

B: 0.69 kg: 25.91 h: 40019

Instrument - MicroCat SBE 37-SMP SN 12053 — 478m

B: 2.2 kg: 3.7 h: 0

Beacon - XEOS SN 30003401 2196220 — 480m

Buoyancy units - CRP 1500/400 Type A +ADCP 1500 (UL) SN 7082

B: -312.15 kg: 522 h: 667

Instrument - Stroommeter AANDERAA RCM11 SN 405 — 730m

B: 19.87 kg: 30.69 h: 62

Instrument - Thermistor SBE56 SN 3951 — 732m

Instrument - Stroommeter AANDERAA RCM11 SN 193 — 981m

B: 19.87 kg: 30.69 h: 62

Instrument- MicroCat SBE 37-SMP SN 12054

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter AANDERAA RCM11 SN 417

B: 19.87 kg: 30.69 h: 62

Instrument- MicroCat SBE 37-SMP SN 12055

B: 2.2 kg: 3.7 h: 0

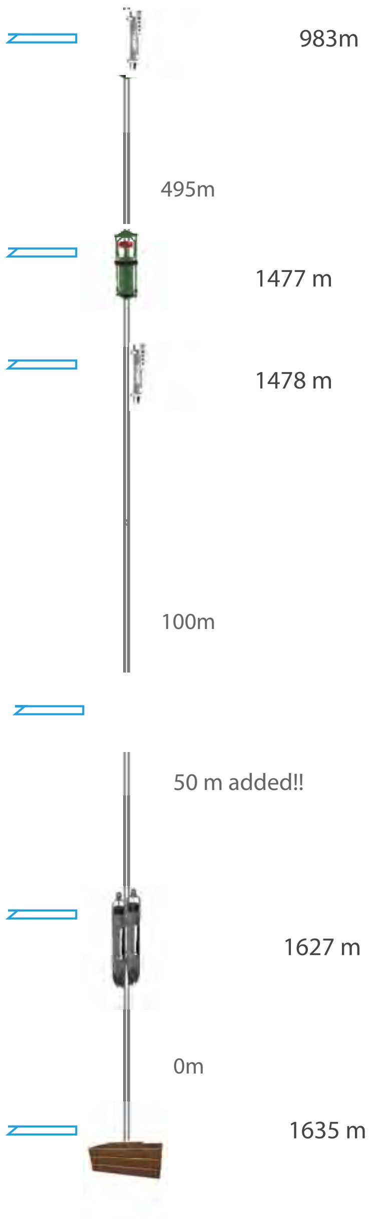
Release- Acoustic Release, IXSEA AR861 B2S
SN 160 ARM 04CF (release code: ARM + 55)
SN 146 ARM 04C1 (release code ARM + 0455)

B: 49.57 kg: 76.5 h: 207.09

Anker - Ankergewicht (600 kg)

Remains on the seabed

B: 610.22 kg: 699.56 h: 558

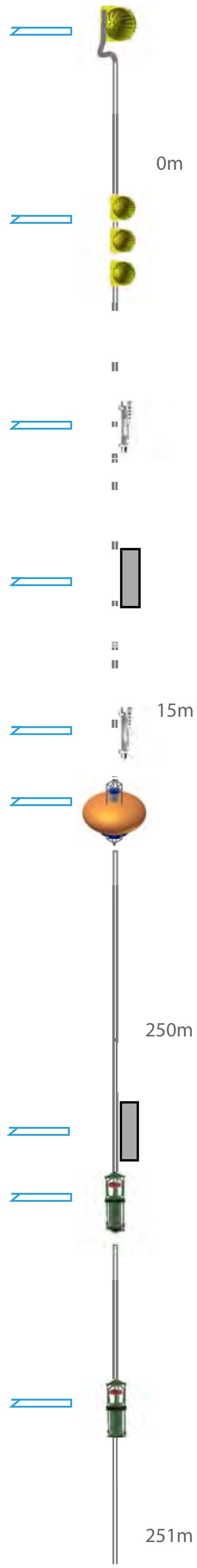


Target position:
latitude: 58° 53.37′N
longitude: 31° 17.84′W

IC4

Deployed on 11 July 2014
at 09:45 UTC
Target depth: 1477 m

Anchor drop:
latitude: 58° 53.12′N
longitude: 31° 1.8.18′W



Buoyancy units - Oppikboei Benthos drijfbol 10 meter — 55m

B: -22.99 kg: 22.04 h: 1098

Buoyancy units - Benthos Spheres, 3 pieces — 65m

B: -70.98 kg: 57.61 h: 227

Instrument - MicroCat SBE 37-SMP SN 12051 — 70m

B: 2.2 kg: 3.7 h: 0

Instrument - Thermistor SBE56 SN 3952 — 200m
Instrument - Dyneema 400 meter +

B: 0.69 kg: 25.91 h: 40019

Instrument - MicroCat SBE 37-SMP SN 2672 — 472m
B: 2.2 kg: 3.7 h: 0

Beacon - XEOS SN 30003401 2279280 — 475m
Buoyancy units - CRP 1500/400 Type A +ADCP 1500 (UL) SN 3641

B: -312.15 kg: 522 h: 667

Instrument - Thermistor SBE56 SN 3948 — 722m

Instrument - Stroommeter AANDERAA RCM11 SN 44 — 724m

B: 19.87 kg: 30.69 h: 62

Instrument - Stroommeter AANDERAA RCM11 SN 245 — 975m

B: 19.87 kg: 30.69 h: 62

Instrument - MicroCat SBE 37-SMP SN 2675

B: 2.2 kg: 3.7 h: 0

Instrument - Stroommeter AANDERAA RCM11 SN 189

B: 19.87 kg: 30.69 h: 62

Instrument - MicroCat SBE 37-SMP SN 8511

B: 2.2 kg: 3.7 h: 0

- Sluiting GPH 1.5ton+ Splitpen

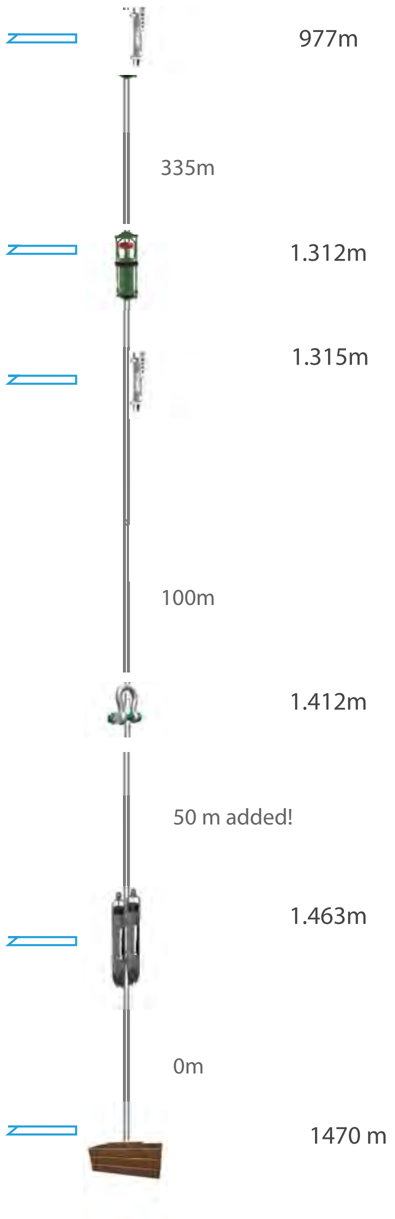
Release - Acoustic Release, IXSEA AR861 B2S
SN 1556 ARM 0A11 (release code: ARM + 0155)
SN 1392 ARM 096F (relaease code: ARM + 0955)

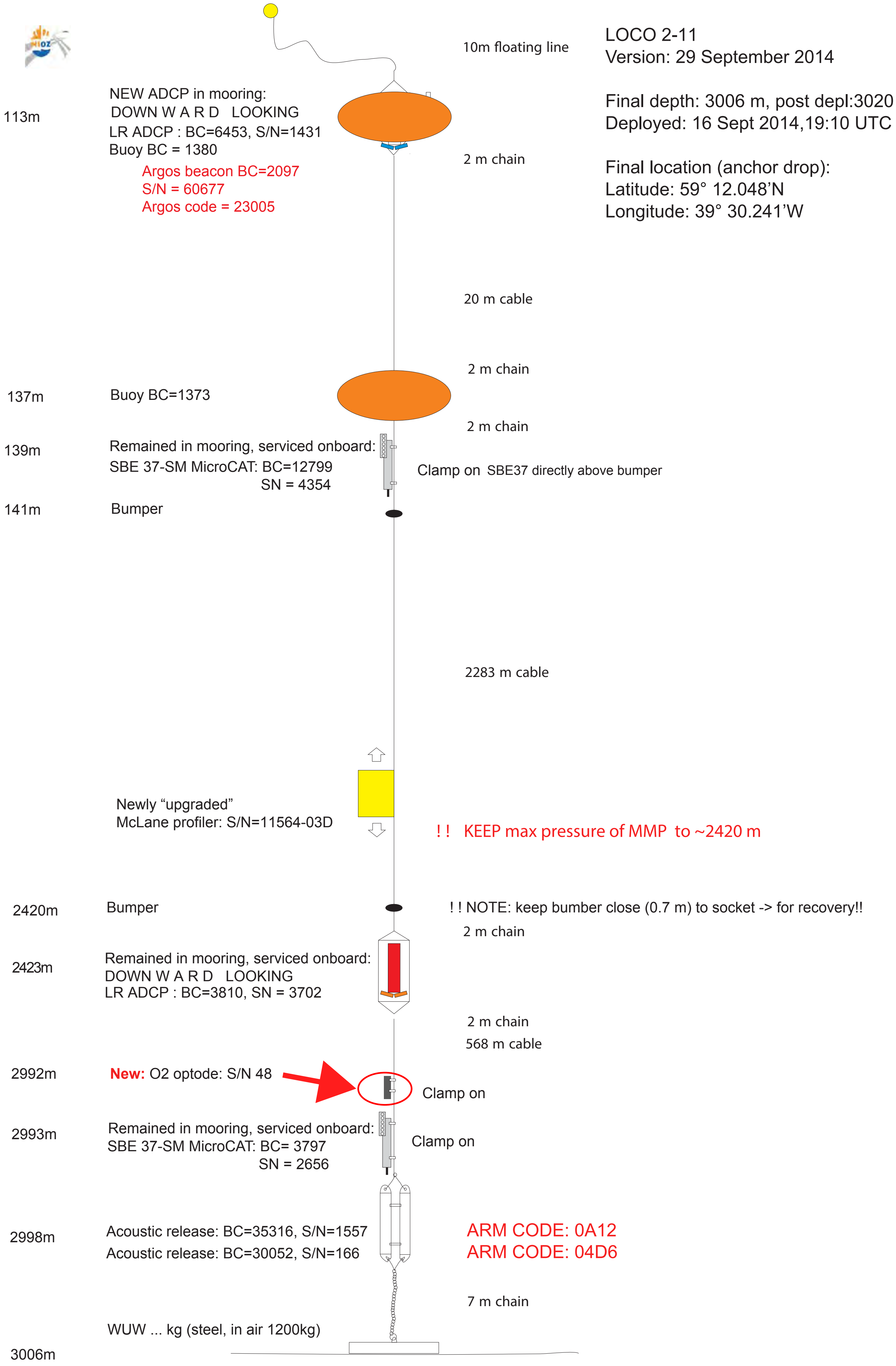
B: 49.57 kg: 76.5 h: 207.09

Anker - Ankergewicht (600 kg)

Remains on the seabed

B: 610.22 kg: 699.56 h: 558




LOCO 2-11
Version: 29 September 2014
Final depth: 3006 m, post depl:3020
Deployed: 16 Sept 2014,19:10 UTC
Final location (anchor drop):
Latitude: 59° 12.048'N
Longitude: 39° 30.241'W
10m floating line
113m
NEW ADCP in mooring:
DOWN W A R D LOOKING
LR ADCP : BC=6453, S/N=1431
Buoy BC = 1380
Argos beacon BC=2097
S/N = 60677
Argos code = 23005
2 m chain
20 m cable
2 m chain
137m
Buoy BC=1373
2 m chain
139m
Remained in mooring, serviced onboard:
SBE 37-SM MicroCAT: BC=12799
SN = 4354
Clamp on SBE37 directly above bumper
141m
Bumper
2283 m cable
Newly "upgraded"
McLane profiler: S/N=11564-03D
!! KEEP max pressure of MMP to ~2420 m
2420m
Bumper
!! NOTE: keep bumber close (0.7 m) to socket -> for recovery!!
2 m chain
2423m
Remained in mooring, serviced onboard:
DOWN W A R D LOOKING
LR ADCP : BC=3810, SN = 3702
2 m chain
568 m cable
2992m
New: O2 optode: S/N 48
Clamp on
2993m
Remained in mooring, serviced onboard:
SBE 37-SM MicroCAT: BC= 3797
SN = 2656
Clamp on
2998m
Acoustic release: BC=35316, S/N=1557
Acoustic release: BC=30052, S/N=166
ARM CODE: 0A12
ARM CODE: 04D6
7 m chain
WUW ... kg (steel, in air 1200kg)
3006m