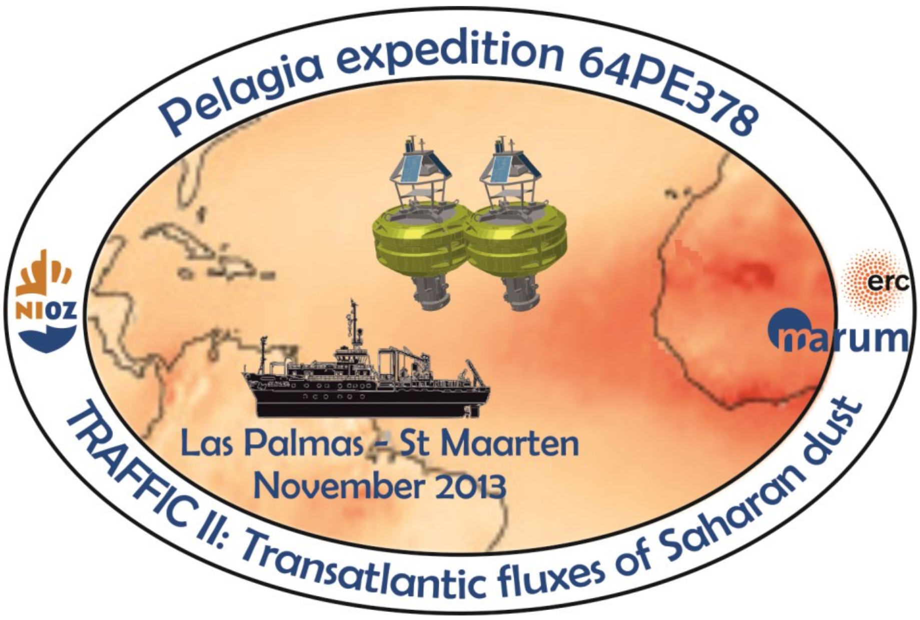
Cruise Report

and preliminary results

TRAFFIC II: Transatlantic fluxes of Saharan dust

Cruise No. 64PE378

9 November – 6 December 2013
Las Palmas de Gran Canaria (Spain) – S[t] Maarten



Jan-Berend W. Stuut, Geert-Jan Brummer, Michèlle van der Does, Carmen Friese, Esmee Geerken, Roald van der Heide, Laura Korte, Bob Koster, Brett Metcalfe, Chris Munday, Jan van Ooijen, Michael Siccha, Ronald Veldhuizen, Jan-Dirk de Visser, Yvo Witte, Leon Wuis

Contents *Page*

1. Summary

RV Pelagia cruise 64PE378 was the second of four cruises within the projects TRAFFIC (NWO funded) and DUSTTRFFIC (ERC funded) crossing the Atlantic Ocean from Cape Verde to the Caribbean. During this transit, a total of ten stations was visited where dust-collecting buoys and sediment traps were deployed and additional water- and sediment samples were taken. The key data of these moorings are listed in the table below.
Due to material damage, of the ten traps that were deployed in 2012, eight were retrieved and five were re-deployed. The new transect consists of one trap at 1200m for positions M1, M2, and M3, two traps at M4 at the original water depths of 1200m and 3500m and no mooring at M5. Sample names start with the year in which most of the sample was collected.

Table 1.1: Key data of the moorings recovered / (re-)deployed during 64PE378

Station	Device	Lat (° ' "N)	Lon (° ' "W)	Depth (m)	Start date
CB	Buoy: Carmen	21°15'49.440"	20°55'18.480"	4200	19 Nov 2013
M1	Mooring M1	11°59'47.778"	23°0'30.366"	5000	23 Nov 2013
M2	Mooring M2	13°48'41.400"	37°49'27.960"	4729	1 Dec 2013
M3	Mooring M3	12°23'45.049"	38°37'39.731"	4680	1 Dec 2013
	Buoy: Michèlle	12°19'29.760"	38°44'36.180"	4621	1 Dec 2013
M4	Mooring M4	12°3'46.386"	49°11'28.417"	4974	9 Dec 2013
	Buoy: Laura	11°57'41.339"	49°4'7.144"	4960	9 Dec 2013
M5	Mooring M5	11°59'57.214"	57°7'56.6"	recovered	only
M5a	Test mooring	11°57'7.200"	56°56'6.000"	recovered	only

The redeployed sediment-trap carrousels in moorings M1 – M4 all started at different dates in order to keep the gap in the sampling series as small as possible. Intervals vary between 8 and 16 days. See paragraph 5.9. Mooring M5a was a test mooring testing a new (dynema-kevlar) mooring line. It was deployed in October 2012 and recovered during this cruise.

2. Participants

Table 2.1: Participants of cruise 64PE378

Name, title	Discipline	Affiliation
Jan-Berend Stuut, Dr	Marine Geology, chief scientist	NIOZ & MARUM
Geert-Jan Brummer, Prof	Paleoceanography, co chief	NIOZ
Michèlle van der Does	Marine Geology	NIOZ
Carmen Friese	Marine Geology	MARUM
Esmee Geerken	Paleoceanography	VU
Roald van der Heide	Marine Research Facilities	NIOZ
Laura Korte	Marine Geology	NIOZ
Bob Koster	Marine Geology	NIOZ
Brett Metcalfe	Paleoceanography	VU
Chris Munday	Marine Geology	NIOZ
Jan van Ooijen	Marine Research Facilities	NIOZ
Michael Siccha, Dr	Paleoceanography	MARUM
Ronald Veldhuizen	Public Relations and Outreach	Freelance
Jan-Dirk de Visser	Marine Technology	NIOZ
Yvo Witte	Marine Technology	NIOZ
Leon Wuis	Marine Technology	NIOZ

NIOZ – Royal Netherlands Institute for Sea Research, Texel, the Netherlands
MARUM – Center for Marine Environmental Sciences, Bremen, Germany
VU – Vrije Universiteit Amsterdam, Amsterdam, the Netherlands

3. Research program

TRAFFIC - Transatlantic Fluxes of Saharan Dust is a project consisting of four transatlantic research cruises designed to monitor and collect Saharan dust that is dispersed across the Atlantic Ocean. The final objective is to study the marine environmental effects of mineral dust deposition.

Cruise PE378 was the second of these four cruises, during which five stations were re-visited at which water- and sediment samples were taken, moorings were recovered and deployed. These moorings are yielding time series of sediment deposition as well as oceanographic data for periods of one year. During this cruise, the array of stations was extended by deploying a moored buoy with dust collector off Cape Blanc as well as at stations M3 and M4 (see map below). Two additional coring stations were added: M0, and M1a. At these two stations, both multi cores and a piston core were retrieved from the sea floor.

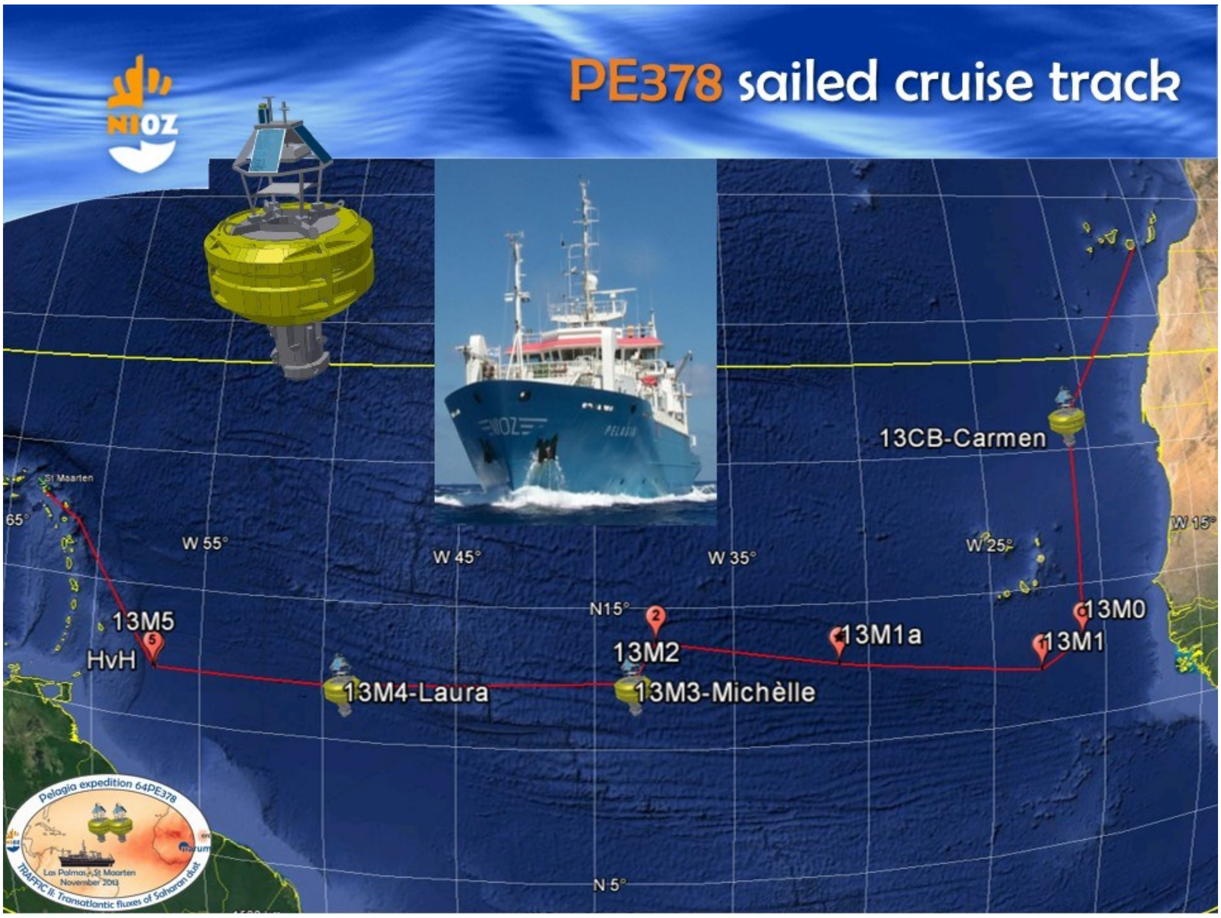


Figure 3.1: Track of RV Pelagia cruise 64PE378. Positions of the five original mooring stations are marked 13Mx, new stations 13M0 and 13M1a were added and sediments (multi- and piston corer) were taken at these two stations. Three buoys were deployed; off Cape Blanc (Carmen) and at stations 13M3 (Michèlle) and 13M4 (Laura).

4. Narrative of the cruise

On Saturday 9 November 2013 the Research Vessel *Pelagia* left the harbour of Las Palmas de Gran Canaria at around 12.00 local time with sixteen cruise participants from various institutions and with various backgrounds. The main purpose of this particular cruise was to deploy three newly constructed surface buoys that are going to collect dust from the atmosphere along the transect that was laid out during last year's cruise on board *RV Meteor* (Figure 3.1). In addition, the moored sediment traps that were deployed last year were going to be recovered, serviced, and re-deployed. Also, sediments deposited on the sea floor would be sampled using a multicorer as well as piston corer. Finally, mineral dust from the atmosphere and plankton from the surface ocean would be sampled continuously along the entire transect.

Directly after leaving the 3-miles zone of Spain, all continuous measurements (thermosalinograph, pump systems, air filtering, and echosounding) were started.

The first station would be the mooring station at Cape Blanc, offshore Mauritania, at about two days of sailing from Gran Canaria. At this station, the MARUM group has been servicing a long-term monitoring station, using two sets of sediment traps, and a score of other oceanographic instruments including current meters, CTDs, fluorometers and optical back scatter meters. In January 2013, a prototype of the dust-collecting buoy had been deployed at this site and it had been sampling mineral dust from the atmosphere for six months until it was ripped from its cable in July 2013. The remaining cable of the prototype surface buoy was recovered successfully, despite some confusion about the actual position of the buoy. Thanks to the sharp sight of Roald (as only one without binoculars he managed to spot the glass floats first!) we found the top float and managed to recover the ~4000m cable. The prototype buoy demonstrated the proof-of-concept of dust collection at the ocean's surface (see §5.8 for more details on the dust-collecting buoys). At the Cape Blanc site, buoy Carmen was deployed successfully on 12 November. It was deployed close to the distal MARUM mooring CBo, at a distance of 11.3 km leeward of CBo, which is about 2½ times the water depth. Although the buoy only just fits under the ship's A-frame, the deployment, led by Yvo and Ger, went really smooth.
Based on seismic profiles of the sea floor's sub-bottom obtained by the MARUM group during previous research cruises (pers. comm. Tilmann Schwenk) it was decided that the sediment stack deposited on this part of the Mauritanian continental shelf is not suitable for long-term palaeo-environmental studies. For this reason, we sampled the sea floor solely with the multicorer. The water column was sampled with a CTD-rosette at 24 depths (see §5.2 for more details on the CTD) and with the multinet (see §5.5 for more details on the multinet).

After almost two days at this site, we sailed south for another two days to arrive early on Saturday 16 November at the new coring station M0, which lies in between our transect at 12°N and the Gambian continental slope which has been studied extensively by e.g., Itambi et al., (2009). Both the multicorer and piston core were deployed at this site, resulting in a 32cm multicore and a 9.30m piston core.

The next stop was the first station of the transatlantic transect at 12°N; station M1 at 23°W and a water depth of 4700m. Due to the fact that we arrived in the late evening of Saturday

16 November, we started this station with deployments for which daylight is not a prerequisite: the multinet and the CTD. After this we started the recovery of the moored sediment traps. The 1200m trap came up like it should and it turned out that all the bottles contained some material: a good catch! However, shortly before the 3500m trap came up, we heard a loud snap and it disappeared back into the deep. It turned out that the upper ring of the titanium bar inside the sediment trap had broken off. It was decided that the upper sediment trap was the most important one, and therefore, the mooring was re-deployed with solely the 1200m trap (see figure 4.1). Also, it was decided to create a break-line across the titanium bar on all traps that were going to be deployed.

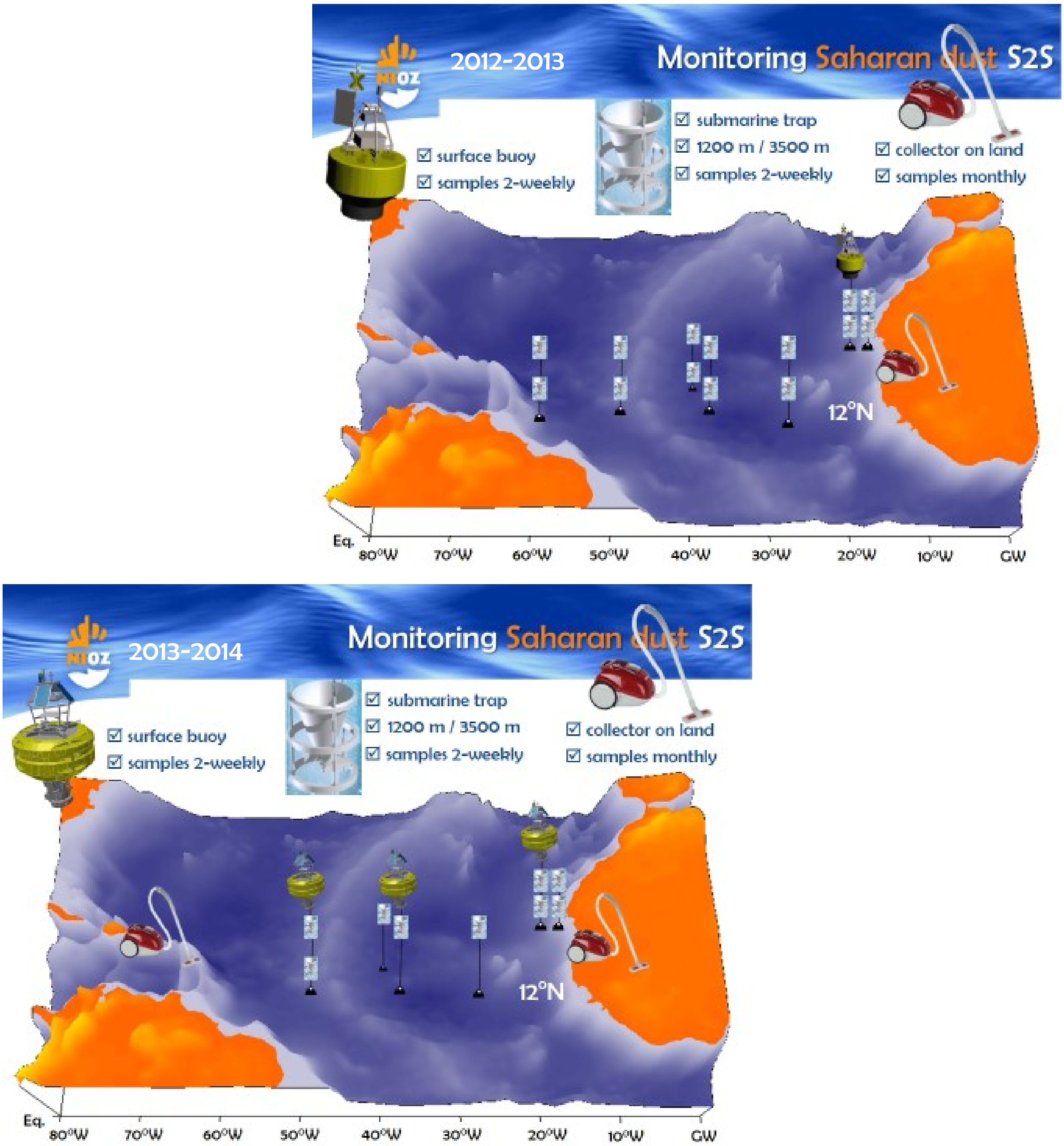


Figure 4.1: Layout of the project. Upper panel shows the moored sediment traps across 12°N and the prototype buoy off Cape Blanc as deployed in October 2012 and January 2013. Lower panel shows the instruments that were deployed during PE378 in 2013.

On to the next station; number M1a, which was also a new coring station at 31°W. We arrived here on the early morning of Thursday 20 November. Thanks to the buoy deployment being a completely new thing for the entire crew, the relatively long search for the recovered mooring, and the restricted speed of the ship, our schedule was running tight. For this reason, it was decided to merge the new coring stations M1a and M2a into a single M1a. The initial multicore that came on deck at 03.30 most likely had tripped too early and therefore, it was decided to try again. The second attempt was much better and yielded sediment cores of 38cm. Based on these results we decided to prioritise a long sediment core at this location and with success: a beautiful 9.54m long sediment core was retrieved from the sea floor. As we had all the facilities to open and scan the sediment cores, we learned that this core contains very clear alternations of layers of all kinds of colours (see figure 4.2). The exact meaning of this will be further investigated with sedimentological and geochemical approaches back home in the laboratory.

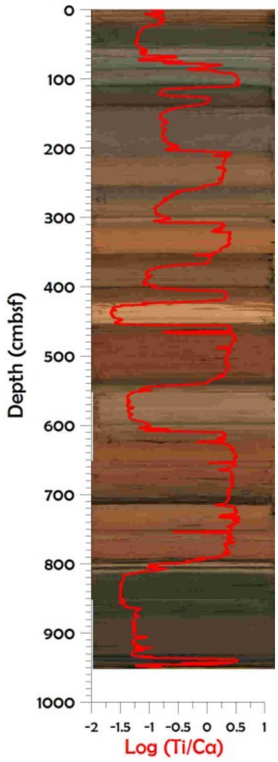


Figure 4.2: Piston core M1A

All this time, the north eastern trade winds kept supplying us with fresh air at a force between 6 and 8 Bft. Although this resulted in tail winds most of the time, some dust could still be collected while on station using the high-volume dust collectors that were put up on the upper deck above the bridge.

Just before lunch on Thursday the 20th, we set sail to station M2 which lies about 400nm further west at about 14°N/38°W and a water depth of 4800m on the African side of the mid-Atlantic ridge. We arrived here on the early morning of Friday 22 November and started with a CTD. This device that samples water through the water column was needed for collecting water for the sediment traps as well as to get a profile of both nutrients and other oceanographic measurements. By the time the CTD was back on deck, dawn had come and we released the weight of the mooring so that it surfaced. This is one of the limitations of recovering a mooring: it has to be done by daylight in order to visually spot the floats at the ocean's surface. All went well and the mooring could be secured, despite the ~2m swell. Bad luck struck at re-deploying the float; it turned out that the sockets of the new cable were not reliable; even with slightly increased stress on the cable, twice they did not hold. This caused a loss of one additional sediment trap. It was decided to not trust the new cables any longer but instead re-use the 1-year old cable that was just recovered from the mooring. This meant an extra few hours delay since the cable had to be re-spooled on the reels in order to turn it downside up again. It also meant that the trap that was prepared to sit at 3500m water depth was now deployed at 1200m water depth.
Station M2 was finally ended with a very nice piston core of 9.24m length.

Figure 4.3. Buoy Michèlle in action

The next station, M3, was relatively close by; less than 100nm, which is about 10 hours sailing. Station M3 would be a very exciting station again, as buoy Michèlle was going to be deployed. First the old mooring was recovered in the morning of Sunday 24 November, with the 1200m trap having suffered from battery issues, due to which it had not rotated at all, and thus contained no samples. Besides, the lower trap came up damaged; the titanium bar inside one of the trap's legs was bent. The sea state was too rough to re-deploy the mooring directly. For this reason, it was decided to start the deployment of the buoy-dummy first. A beacon with light was installed on the smartie so that it could be followed during the night and the buoy could be attached to it on the morrow of the next day. Fortunately, the next day the wind had slackened and the swell was a bit less, so that Yvo Witte and his team could deploy buoy Michèlle very smoothly on the late morning of Monday 25 November. That same day also the mooring was re-deployed with –just like the previous two stations— solely the upper trap at 1200m.

We could relax a tick while on transit to station M4, which lies 620nm west of M3, about 2½ days of sailing. The further westward we got, the calmer the wind and sea became as well; good conditions to recover and deploy these big and heavy instruments. We arrived at M4 on Thursday 28 November in the early morning and proceeded directly with the deployment of buoy Laura. Also this deployment went very smooth: just after lunch buoy Laura floated happily in the western equatorial Atlantic.
We proceeded with the CTD and multinet; instruments for which daylight is not required. Poor Brett and Michael undoubtedly have the record of nightly deployments with their multinet. In addition to this, Brett also sampled the surface ocean for foraminifers using the ship's fire hose connected to his sieves four times per day. Bob undoubtedly has the record of early rises for also at M4 we started at daybreak with the retrieval of the moored sediment traps. The sounding of the IXSEA releasers was an alarm clock for many. The mooring was recovered successfully and both the traps and all the other instruments had done a wonderful job during the past year. Apparently there were two events which caused the sediment-trap bottles to be almost completely full at bottle 12 (related to hurricane Sandy?) and bottle 24. Also the re-deployment of this mooring went very smoothly so that station M4 is the only one with a complete set of instruments, albeit with only one releaser.

After having started with a CTD at station M5 on Sunday 1 December bad luck struck again; despite a relatively flat sea and a calm swell of maybe half a meter, the titanium rod of the sediment trap broke once again. It was clear that with this failure, the 1200m sediment trap was lost. However, there was still one smartie that could hold up the lower trap and other instruments. "Could". We were not sure about this, as the smarties are designed to float until a water depth of 1500m but this smartie must have stood at 2000m below the sea surface.

With an optimistic approach, we assumed that the remaining line would still be upright and we started dredging. However, as we would like to know if we caught the big fish, it was decided to use the Kevlar cable from the side, which has the possibility to measure strain on the cable. The problem was that we had to sail around the position of where we had determined the releasers to stand, based on triangulation. With the cable from the side this turned out to be hardly possible as the cable was pulled under the ship, dangerously close to the propeller. For this reason, our low expectations were right when the dredge anchors came up.
On Tuesday 3 December we continued our program with the test mooring that we had deployed last year for NIOZ colleague Hans van Haren, after having obtained bathymetric measurements all night using the multibeam system.
Next to the smooth recovery, also a 4.89m piston core was retrieved from the sea floor. These successes changed our mood to a very optimistic one and we once tried dredging, now from the hind deck to avoid the cable problem.

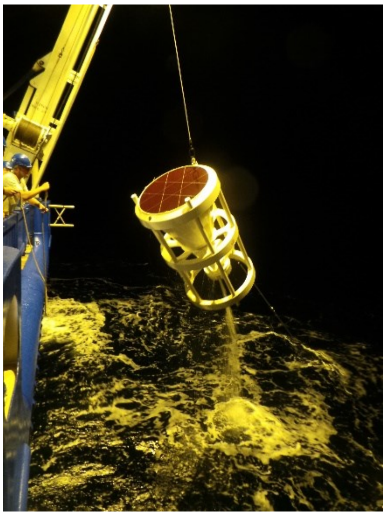


Figure 4.4: Trap ahoy!

Thanks to the USBL communication that Bob Koster managed to set up –so that we could determine the position of the dredge anchors— as well as the perseverance of Roald van der Heide –who spent all afternoon on the bridge to help the officers navigate the dredge anchors around the mooring line— we were successful this time; shortly before midnight of the 4 December we spotted the smartie and the mooring could be saved. Thanks to the dredging, the cables were a tick damaged but there would not have been time anyway to re-deploy this mooring. We were very happy to have retrieved the sediment trap at all! Our victorious feelings were even emphasised by the fact that the trap had worked perfectly; all cups contained mud: Saharan dust?

Not a minute was wasted to set course to our end station: St Maarten, where we arrived in the early morning of 6 December.

All in all the cruise can only be called eventful; lots of bad luck with weather and materials but also lots of stamina and patience, awesome creativity, which have resulted in very nice samples to study. The successes are clearly the result of a very pleasant and efficient collaboration between the ship's officers and crew and us "opstappers", for which I thank you all.

6 December, off St Maarten, Caribbean,
Jan-Berend Stuut

5. Preliminary results

5.1 *Multi-beam mapping*

Bob Koster & Jan-Berend Stuut

The shipboard KONGSBERG multi-beam echo-sounder EM302 was operated at all five stations to add bathymetric information to the already existing maps that were acquired during cruise M89 in 2012. This was mostly done autonomously by the ship's officers while at station and waiting for sunrise. The processing of the raw data was carried out at NIOZ by Yvonne Grachten and Dr. Henk de Haas, using the sound-velocity profiles resulting from our own CTD casts at the stations. The bathymetric maps produced on the basis of the multibeam data acquired during M89 were expanded.

The EM302 system is a swath multibeam system with ping and chirp mode and a seapath GPS and motion sensors, 1° x 2°, 30kHz, with a swath of 4200m at a water depth of 5km. It is heave-pitch-roll compensated. Depth uncertainties are less than 0.5 % of the water depth. The raw-data output of the system was backed up automatically. Subsequently, at NIOZ, the data were transformed into ASCII formatted latitude-longitude-depth files. These data are archived at NIOZ.

The here-presented maps are of extremely poor quality, are not geo-referenced, have no bathymetric isolines nor a legend. During cruise 64PE395, additional multi-beam mapping will be carried out in order to expand these maps. Processing of the bathymetric data of three cruises (M89, 64PE378, and 64PE395) will be carried out at the MARUM in Bremen.

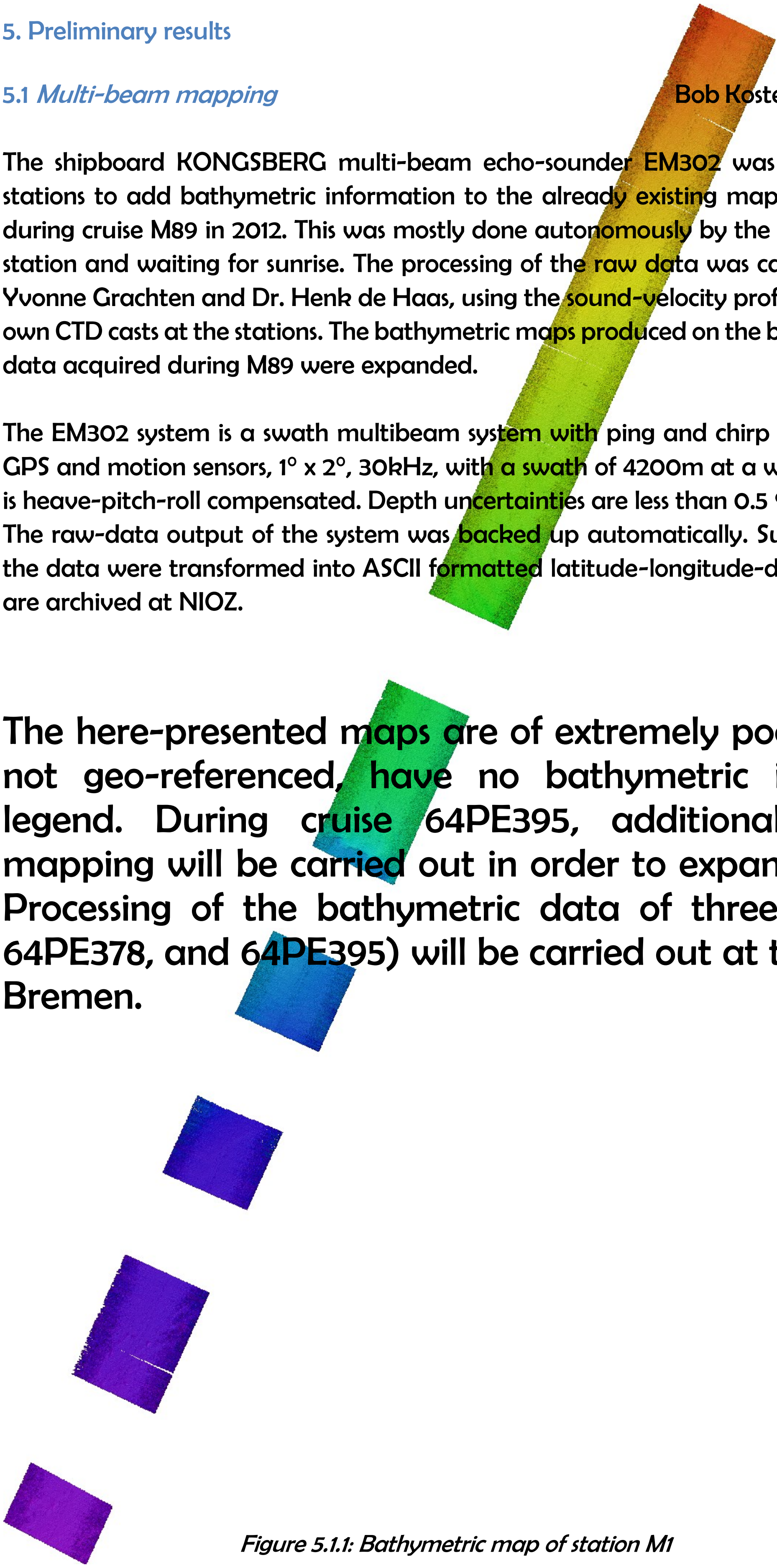
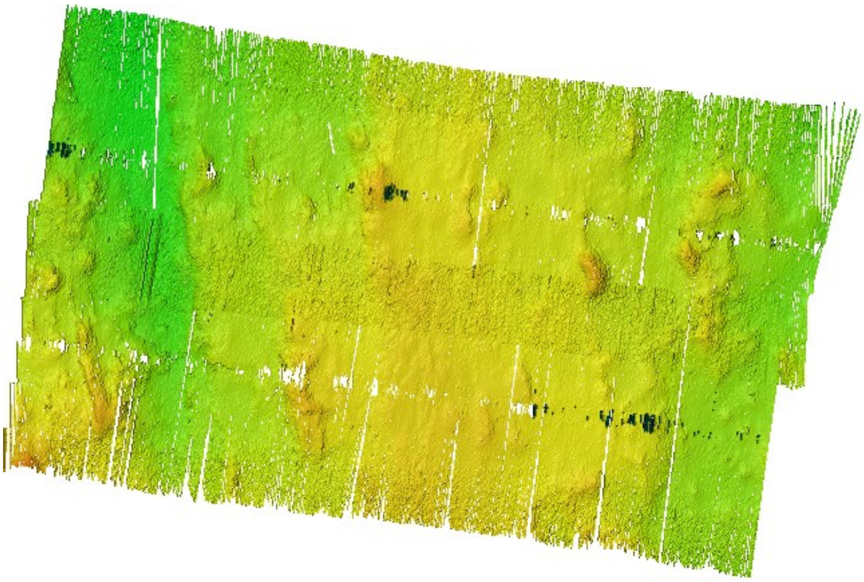


Figure 5.1.1: Bathymetric map of station M1



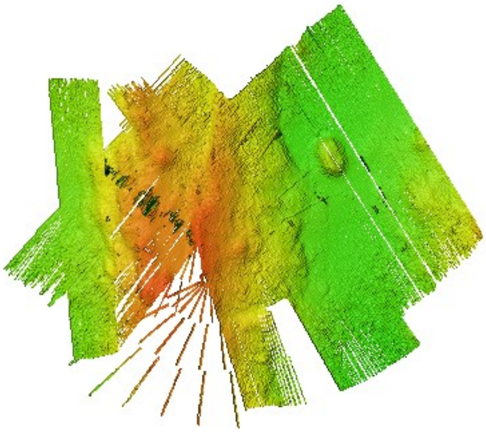


Figure 5.1.2: Bathymetric map of station M2

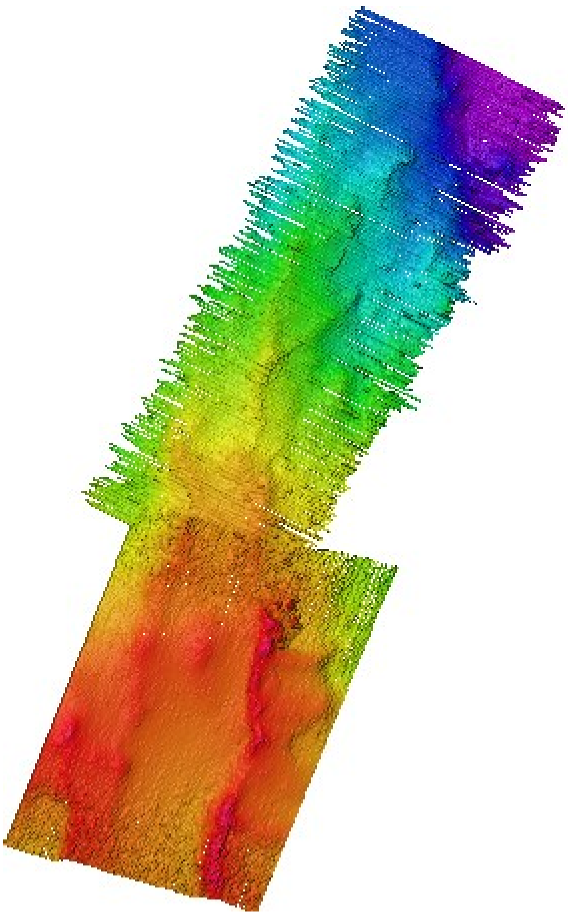


Figure 5.1.3: Bathymetric map of station M3

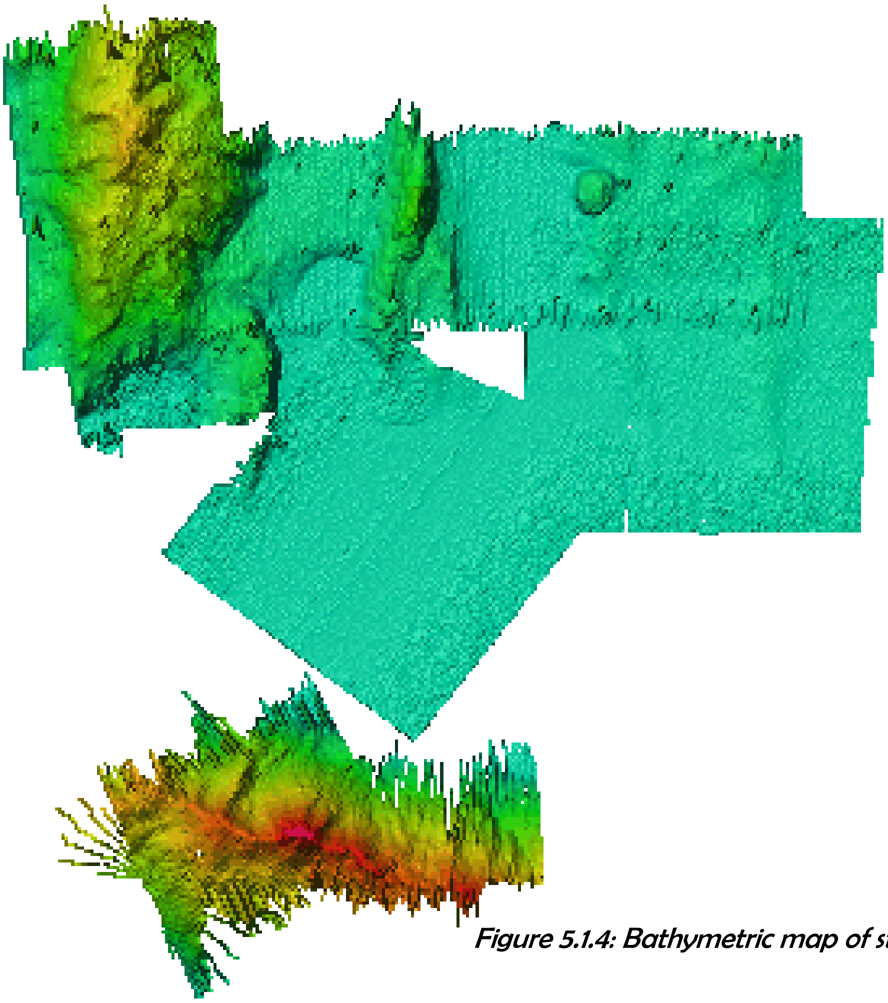


Figure 5.1.4: Bathymetric map of station M4

Figure 5.1.5: Bathymetric map of station M5

5.2 *Water sampling and CTD*

Carmen Friese

A Sea-Bird SBE911-Plus Profiler, in conjunction with a SBE32 24-position Multi Water Sampler for 12-liter bottles (“rosette”) was deployed at station 13CB-3, 13M1-2, 13M2-1, 13M4-2 and 13M5-1 (Table 5.2.1).

Table 5.2.1: Station specifications of the CTD casts during PE378.

Station No.	Cast no.	Water depth [m]	Lat [°N]	Lon [°W]	Date [d/m/y]	Time start [UTC]	Time end [UTC]	CTD file name
13CB	3	4200	21°16.61	20°55.14	12/11/13	17:30	21:00	13CB3.hex
13M1	2	5040	12°0.89	23°0.85	17/11/13	01:30	05:40	13M1_2.hex
13M2	1	4884	13°48.70	37°49.80	22/11/13	01:20	07:15	13M2_1.hex
13M4	2	5040	11°58.96	49°57.94	28/11/13	21:35	01:10	13M4_2.hex
13M5	1	4428	11°57.25	56°54.20	01/12/13	19:37	22:45	13M5.hex

The SBE911-Plus Profiler was equipped with a conductivity, temperature (pumped), pressure, oxygen, chlorophyll, and transmissivity sensor (Table 5.2.2).
All sensors registered their specific observations online through both the down- and up-casts. The CTD data was used for the sound-velocity profiles required for the multi-beam system. Based on the results of the obtained CTD sensor data (e.g. oxygen, temperature, salinity and chlorophyll concentrations in the water column) the depths for subsequent multinet casts were chosen (Figure 5.2.1).

Table 5.2.2: Type and serial number of the CTD sensors employed during the cruise.

Parameter	Sensor type	Serial number
Conductivity [S/m]	SBE4	40776
Temperature [°C]	SBE3	4384
Pressure [db]	SBE 9plus	53978
Dissoloved oxygen [µmol/Kg]	SBE43	431932
Chlorophyll [µg/l]	Chelsea fluorimeter	088-008
Transmissivity [%]	wetlabs C star	CST-1112dr

The CTD system was mounted on the 8-mm steel wire of the CTD winch. It was used in on-line mode, i.e., during the cast all data was directly sent to the pc on board the ship where they were registered and stored. The motor-driven water sampler was connected to the deck command unit via the single-core, armoured cable of the winch, thus, allowing to remotely control each cast. The bottles (N=24, on a 24-position trip mechanism) were tripped during the up-cast at chosen depths using the acquisition software of the CTD (Seasafe remote). The water samples were used for the preparation of the sediment trap deployments, nutrients, isotope, DNA, TSP (total suspended particle) analysis and for further trap studies at the NIOZ.

At the beginning of each deployment, the CTD was held at the surface for at least 1 minute (“CTD soaking”) to get rid of the air in the pump system. Afterwards, the CTD and rosette were lowered with a speed of 0.9 m/s. During a cast the ship was held on position.

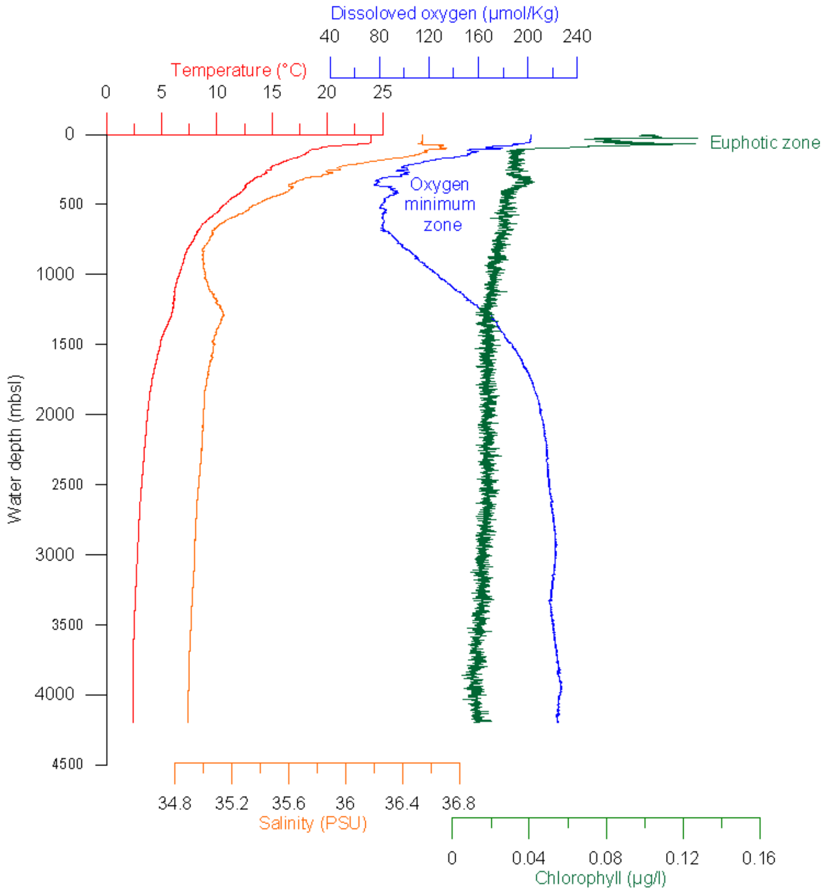


Figure 5.2.1: Results of the CTD sensor data acquisition: Temperature, Salinity, dissolved oxygen and chlorophyll concentration with depth at site 13CB-3.

The depths at which the bottles were to be tripped were chosen as follows.

One objective was to collect three water samples each in 1250 and 3500 m water depths (N = 6 bottles, bottle no. 3-5 and 9-11). This is the depth at which the sediment traps were moored during the previous cruise (M89) as well as at which depths the sediment traps were going to be redeployed during the present cruise. Thus, water samples were needed in order to

- prepare the new sediment trap deployments
- split the obtained sediment trap samples for trap studies at the NIOZ institute
- spare sample

In addition, the water samples were used for nutrients, TSP and DNA analysis.

Further water samples were taken in certain depth intervals for nutrient and TSP analysis (N=18 bottles, bottle no. 1,2,6-8,12-24).
The water depths were chosen as follows.

- Euphotic zone (0-100 m): Highest spatial resolution with 10, 25, 50, 75 and 100 m wd since most vertical changes in nutrient and TSP concentration occur in this water layer
- 100-300 m wd: 50 m depth intervals
- 300-500 m wd: 100 m depth intervals
- 500-1750m wd: 250 m depth intervals
- 2500-5000 m (max.) wd: 500 m depth intervals

The water samples gathered from the upper 3 water depths (N= 3 bottles, bottle no. 22-24) were also used for isotope analysis (δD).

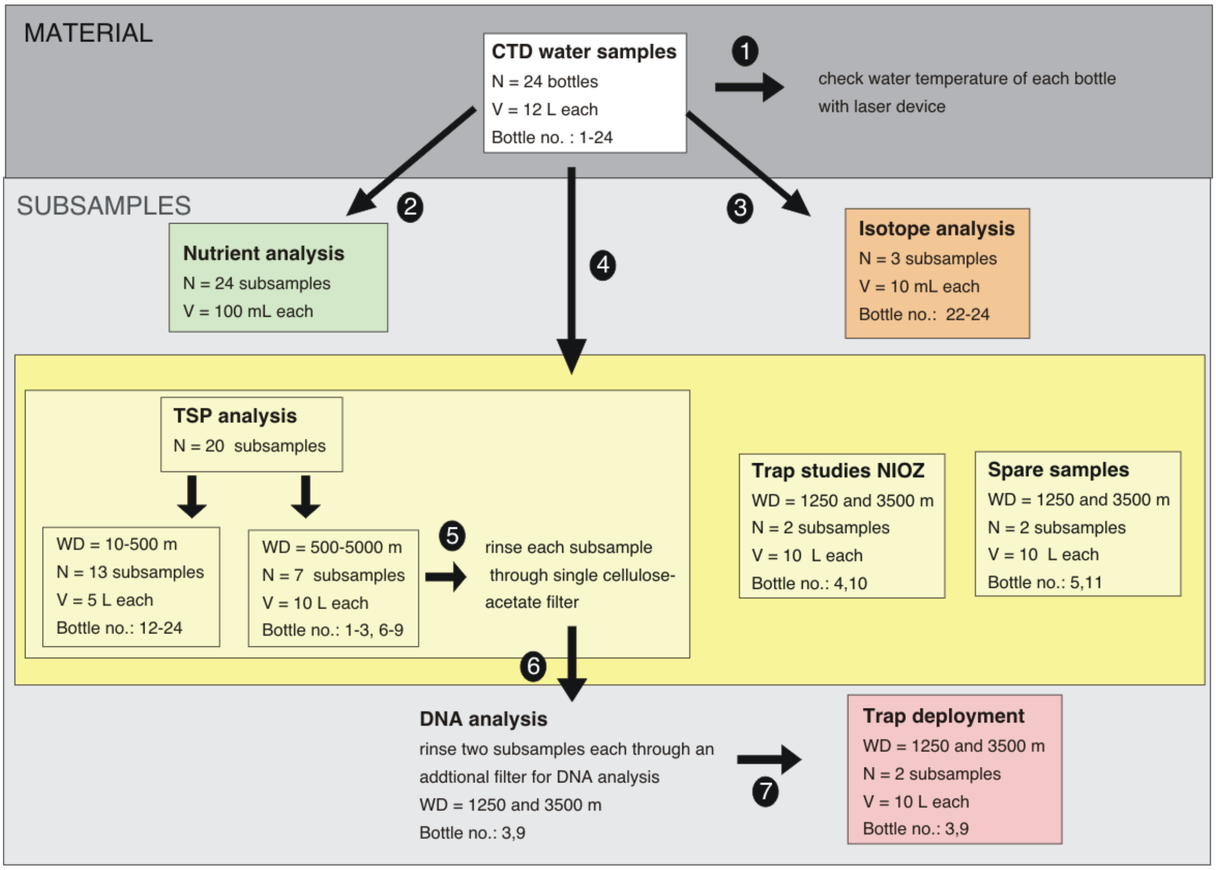


Figure 5.2.2: Working procedure to subsample the water bottles of the CTD rosette. The subsamples were gathered for nutrient, isotope, TSP and DNA analysis as well as to prepare the new sediment trap mooring deployments and to split recovered sediment trap samples at NIOZ.

After the cast, all devices were rinsed with freshwater. The water bottles were treated as follows (Figure 5.2.2):

1. Instantly, the water temperature inside the bottles was measured with a laser thermometer in order to check whether the bottles closed at the correct depth.
2. A subsample of 100 ml was retrieved from all bottles for nutrient analysis. Subsequently, Jan van Ooijen measured the nutrient concentration (phosphate, silicate, ammonium) in the nutrient lab on board Pelagia (Figure 5.2.3).
3. A subsample of 10 ml was retrieved from bottles 22-24 for isotope analysis.
4. Further subsamples:
    a. 10 L jerrycans were filled from bottles 4 and 10 for trap studies at NIOZ
    b. 10 L jerrycans were filled from bottles 5 and 11 to gather spare samples
    c. 5 L jerrycans were filled from bottles 12-24 and 10 L jerry cans from bottles 1-3 and 6-9 for TSP analysis. Owing to the higher concentration of TSP in the upper water column only 5 L of subsamples were needed for subsequent filtering. Bottles 3 and 9 were also used for DNA analysis.
5. Each subsample for TSP analysis was rinsed through a single cellulose-acetate filter (Fig. 4).
6. Bottles 3 and 9 were not only rinsed through polycarbonate (PC) filters for TSP analysis but also through a PC filter for DNA analysis.
7. The water filtered at the depth of the sediment trap deployments for TSP and DNA analysis (10 l, bottles 3,9) was subsequently used in order to prepare the new sediment traps.

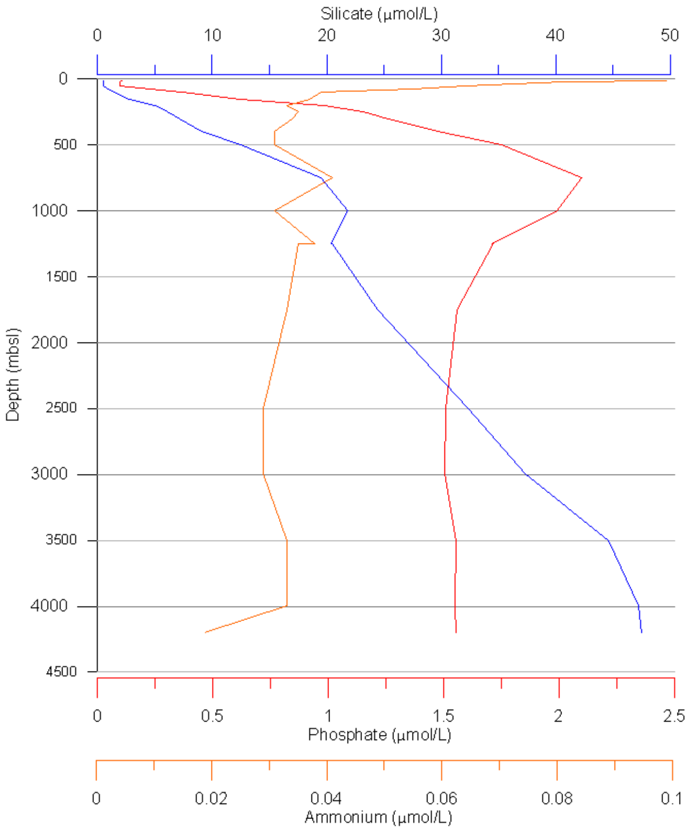


Figure 5.2.3: Nutrient concentration (phosphate, silicate, ammonium) with depth at the site 13CB-3. The subsamples for nutrient analysis were obtained from the water bottles of the CTD rosette.

The exact closing depths of the bottles, the subsamples gathered from each bottle and the amount of water filtered for TSP and DNA analysis are given in tables X (appendix) for each station.

The bottom alarm of the CTD failed at sites 13CB-3, 13M1-2 and 13M2-1. At sites 13M4-2 and 13M5-1 the alarm functioned properly.
At site 13CB-3 no sediment trap mooring was recovered and redeployed. Hence, no subsample for the treatment of the sediment trap samples was obtained.
At site 13M2-1 four bottles were closed at the depth of the sediment trap deployments instead of three. This was done in order to gather additional water samples for the sediment trap mooring at station 13M3-1 where no CTD was going to be deployed.

(a)

(b)

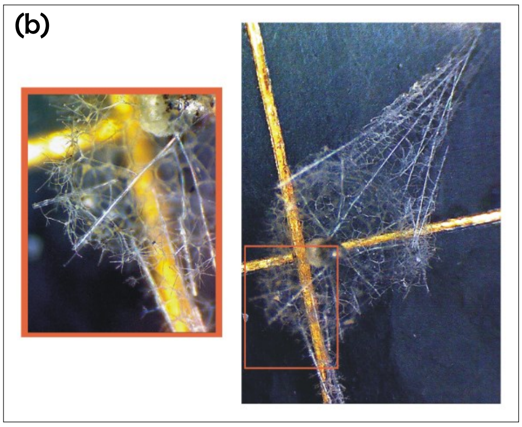


Figure 5.2.4 (a): Filtration of seawater in the lab on board RV Pelagia, (b): Radiolaria discovered on filter after filtration of seawater obtained at station 13M2-1, 9 mbsl (bottle 24).

5.3 *Sediment sampling with the multicorer*

Michèlle van der Does

At stations CB, M0 and M1A, a multicorer was deployed in order to recover the sediment-water interface and undisturbed sediments from the seafloor. At stations M1, M2, M3, M4 and M5, no multicore samples were taken, since they were already taken during the previous TRAFFIC cruise in October 2012 (RV Meteor Expedition M89). The multicores will also be used in combination with the long piston-cores, since their upper sediments are often disturbed. The multicorer consisted of 12 tubes of about 60cm with a diameter of 10cm. Two of these tubes were made of grey plastic and ten were made of fully transparent Perspex.

The multicorer generally worked very well, resulting in 30-45 cm long sediment cores. The multicorer has all the weights attached, which gives it a total weight of ~500 kilograms.

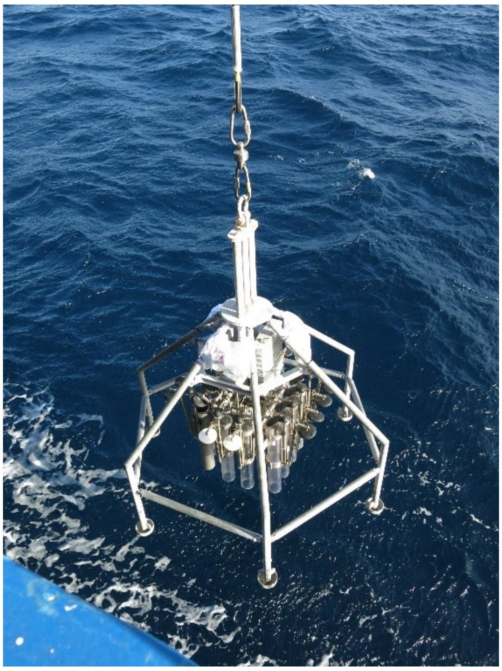


Figure 5.3.1: The multicorer in action

At station M1A the multicorer retrieved only 2 cores with only very little sediments (~4cm), and it was decided that the multicorer would be deployed again. This resulted in a successful set of sediment samples.

The cores of each multicorer deployment were subdivided as follows:

- The two longest cores were sliced into 1-cm slices and stored in Ziploc bags
- 1-2 grey plastic cores were cut length-wise, and XRF-scanned
- of ~4 cores the surface was sampled, and stored in Ziploc bags

All the aforementioned samples and cores were stored at 4°C

- The third longest core was kept in its Perspex tube and frozen at -20°C as an archive core. After 48 hours, the core was transferred into a plastic bag and kept frozen

Preliminary XRF results

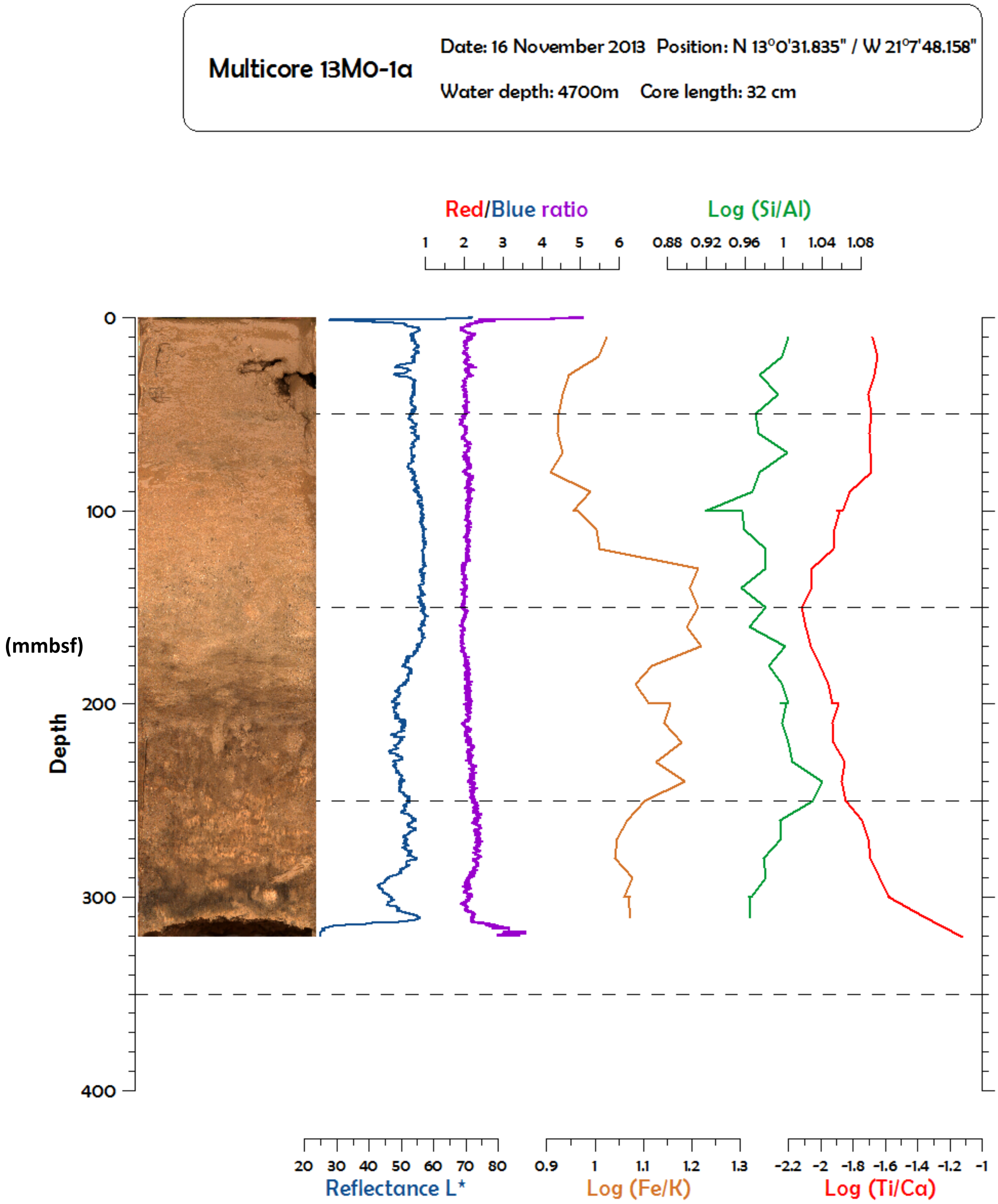


Figure 5.3.2: Line- and colour scan plus XRF data for core 13MO-1a

Multicore 13MO-1b	Date: 16 November 2013 Position: N 13°0'31.835" / W 21°7'48.158" Water depth: 4700m Core length: 30 cm

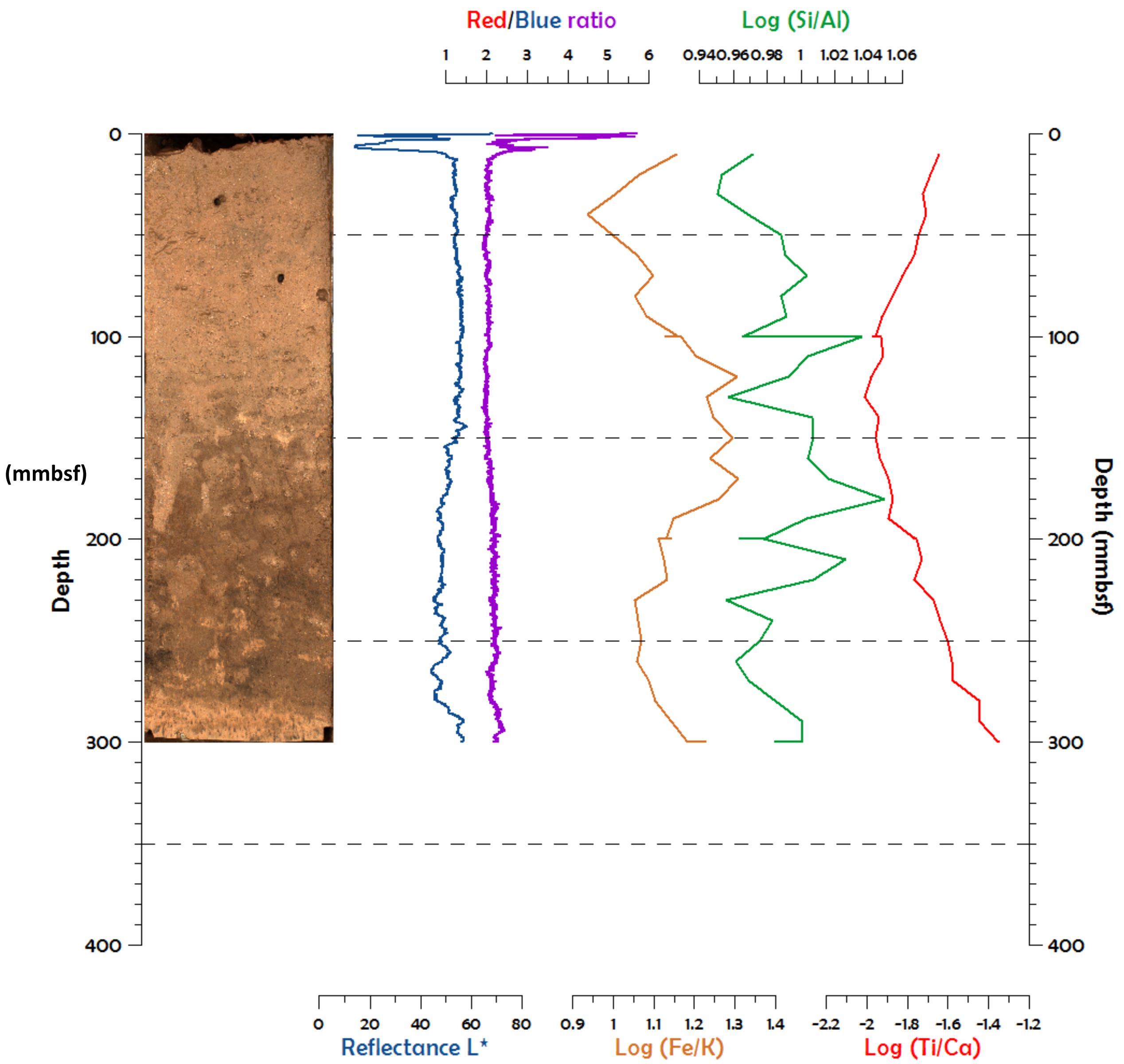


Figure 5.3.3: Line- and colour scan plus XRF data for core 13MO-1b

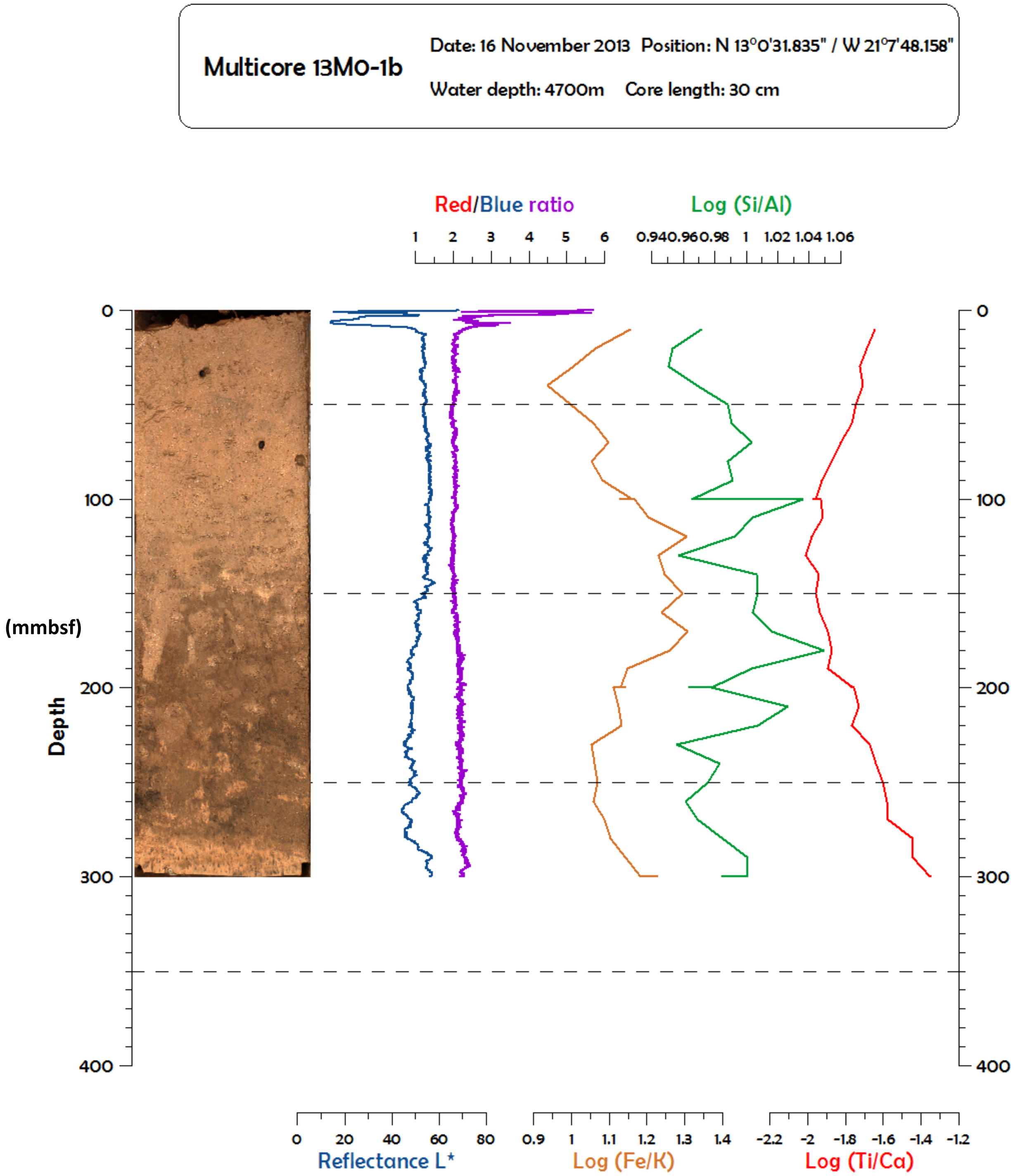


Figure 5.3.4: Line- and colour scan plus XRF data for core 13M1A-2

At station MO-1, two of the cores were scanned in the XRF-scanner, and these results can be compared and used to test the reproducibility of the XRF scanner and the multicorer (cores MO-1a and MO-1b). The two records are plotted together in Fig. 5.3.5 below, and it can be seen that the records compare very well. This illustrates the good reproducibility and the similarity of different cores from the same multicore cast.

Multicore 13MO-1a / 1b	Date: 16 November 2013 Position: N 13°0'31.835" / W 21°7'48.158" Water depth: 4700m Core length: 32 cm

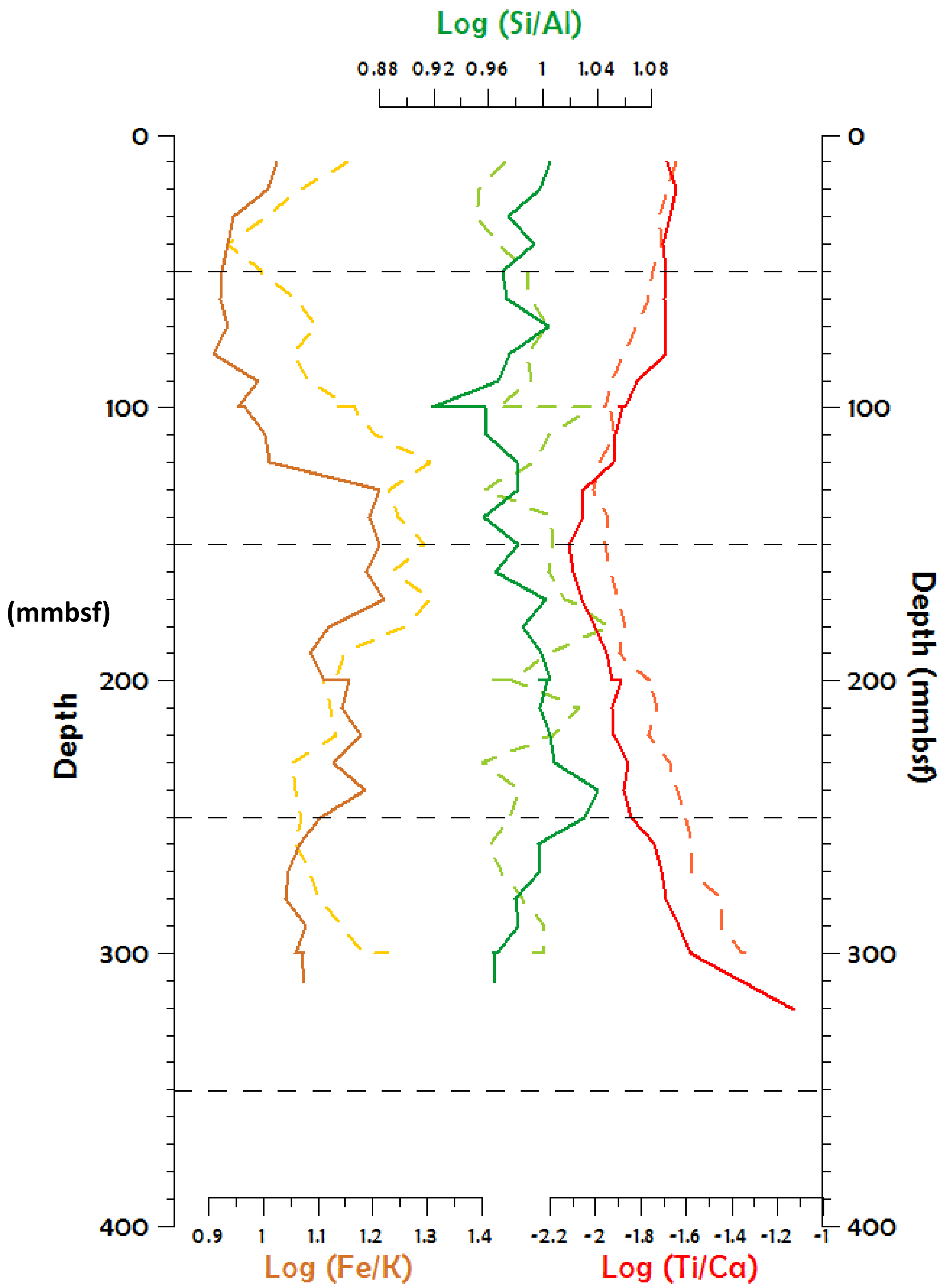


Figure 5.3.5: XRF records of 13MO-1a and 13MO-1b, illustrating the method's reproducibility

5.4 *Sediment sampling with the piston corer*

Esmee Geerken

Piston core samples were taken at stations M0, M1, M1a, M2, M4 and M5. Although it was initially planned to take a piston core sample at station CB, eventually no core was taken because the continental slope at this location turned out to be heavily disturbed by turbidites and mass flows.

General Methodology

The steel piston corer with a special, thick (6 millimeters), PVC liner was lowered to the seabed to collect sediments and retrieved on board. We cut the piston core liners in sections of 1 meter starting from the bottom and this usually resulted in a smaller core top section. For the first four piston core samples, we applied labels before cutting the sections in half with the new core cutter specially developed at the NIOZ, dividing them into two halves: a work and an archive part. For the last two piston core samples we decided to first cut the sections and then pick the prettiest half as the archive part. In all cases the best-looking section halves were smoothened and then line-scanned with the Avaatech XRF core scanner as soon as possible to avoid decolouration due to reactions with oxygen. After we encountered a strangely tilted part in piston core M2 (figure 5.4.1), we decided to line the upcoming piston-core sections with a marker so we could cut each along the same axis, providing more consistency.

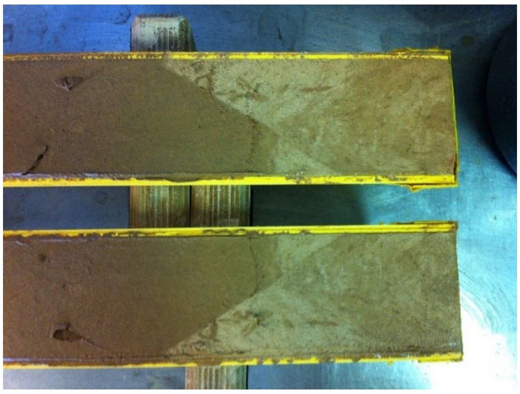


Figure 5.4.1: Piston core 13-M2-4 contained a mysterious tilted section which we think is a distortion in the piston core. After seeing this it was decided to cut all sections of the liner along the same axis.

Energy dispersive fluorescence scans (X-Ray Fluorescence or XRF) were done with an Avaatech core scanner to reveal the bulk chemistry of the cores. Before applying the Ultralene core scanning foil, sections were left open to warm up to avoid condense formation. Because the scanner only measures the top micrometres, a water film covering the surface would distort the chemical signal. To obtain the maximum spectrum of elements, we scanned the core on three energy levels: 10, 30 and 50 KeV (see table 5.4.1 for details). Unfortunately the X-ray tube could not stabilize the high current (2.0 mA) initially requested to gain enough counts, because of its age. We therefore lowered the current as much as was needed for it to stabilize: this turned out to be 0.850 m. After XRF scanning was completed, we covered the cores with cheese foil, wrapped them and stored in labelled D-tubes at 4°C.

The XRF data was processed with the WinAxel Batch program. The log (Fe/K), Log (Si/Al) and Log (Ca/Ti) ratios as well as a picture from the core and the reflectivity and Red/Blue ratios retrieved from the line scan data file can be seen for all stations in the figures presented in the following section.

Table 5.4.1: XRF set up details

Run	Current	Filter
10 KeV	0.750 mA	1- no filter
30 KeV	0.500 mA	3-Pd-Thin
50 KeV	0.850 mA	5-Cu

Station details

At station M0, cast 2, the technicians retrieved a piston core of 9.30 meters from a depth of 4700 meters. The middle part of the core resembles a marble cake pattern, as can be seen in figure 5.4.2., which points to the occurrence of turbidites or mass flows/ slumps that ruin the sedimentary sequence. The chemical signal of this part appears to be smoothened out. The top layers show sedimentary layers and a more varied chemical signal.

Piston core 13M0-2	Date: 16 November 2013 Position: N 13°0'31.95" / W 21°7'48.11" Water depth: 4716m Core length: 9.30m

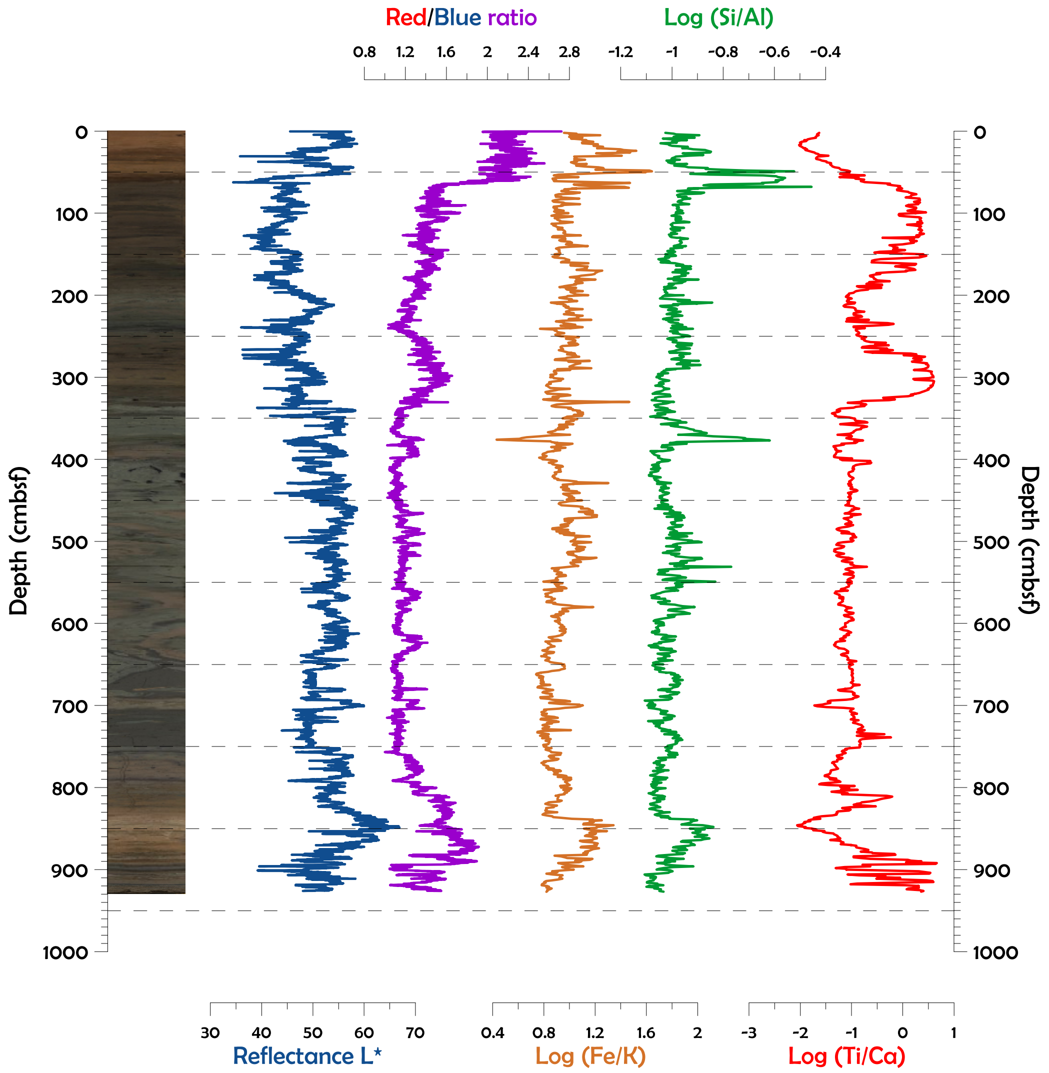


Figure 5.4.2: Piston core 13-M0-2 graph showing the line scan, reflectance and red/blue ratio from the line scans and log (Fe/K), log (Si/Al) and log (Ti/Ca) ratios derived from the XRF scans. The middle section (±700-300 cmbsf) is probably disturbed by turbidites. The top and bottom layers resemble a sedimentary signal.

At station M1, cast 4, the piston corer hit a hard, sandy layer and only penetrated a meter of seafloor, after which it tilted over and dropped on the seafloor, resulting in deformed piston corer bomb. Only 30 cm of heavily distorted sediments were left in the liner. It was decided to only make a line scan (figure 5.4.3.) and leave the XRF-scan since this core is not likely to be used in further analysis.

Figure 5.4.3: Line scan of piston core 13-M1-4. The bulk chemistry was not analysed with XRF because of the disturbed sediments.

At station M1A, cast 3, we retrieved a beautiful piston core sample of 9.54 meter from a depth of 5871 meters. Figure 5.4.4. shows darker, lighter and yellow/reddish bandings that nicely line up with the element ratios. The material is fine grained.
The orange layers possibly show the influence of the African continent: wind-blown Saharan dust as well as material eroded by rivers might have been transported far offshore.

The log (Ti/Ca) ratio, pointing towards a more terrestrial versus marine biogenic sediment source (for this region), varies trough the depth of the core. The log (Si/Al) ratio, pointing towards a more aeolian versus a more fluvial origin of the sediment, shows spikes as well as the log (Fe/K) ratio, along with the darker layers. Further analyses on the meaning and the age of these signals will be performed at the NIOZ and at the VU after the cores are shipped back home.

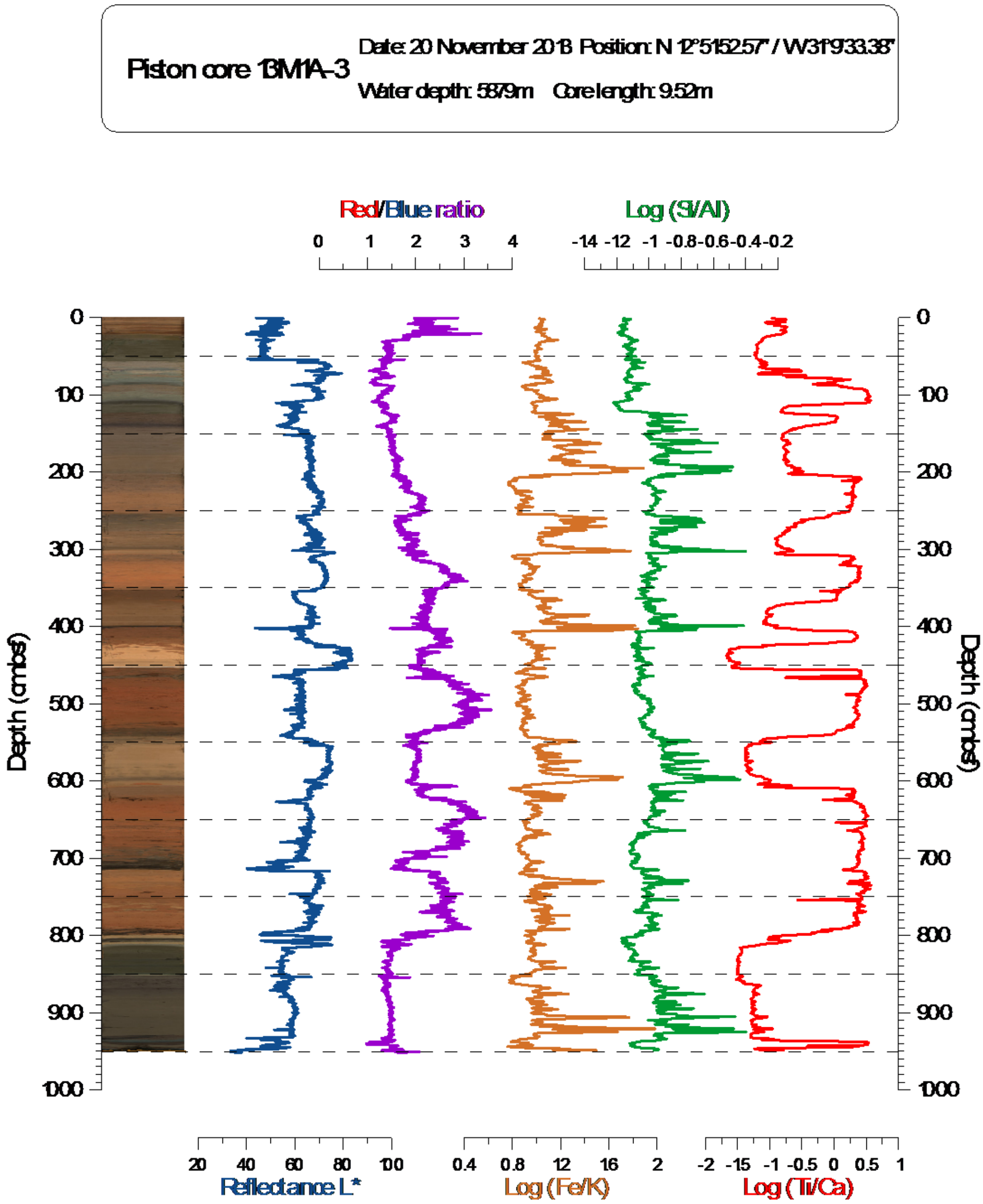


Figure 5.4.3: The line scan, reflectance l and Red/Blue ratio retrieved from the line scan and the log (Fe/K), Log (Si/Al) and Log (TI/Ca) ratios derived from the XRF scan of piston core 13-M1A-3. The core shows a highly variable signal in colour as well as element composition and is fine grained.*

At station M2, cast 6, a piston core sample of 9.24 meters was retrieved from a depth of 4749 meters (figure 5.4.5.). The core looks fairly homogeneous with three lighter, calcium-rich bandings that as can be seen and felt contains a lot of foraminifera. The last piston core just before the mid-Atlantic ridge still shows yellowish colours. Further analysis back home will hopefully reveal the influence of windblown Saharan dust on the sediment. Will the upcoming piston cores still show some dust?

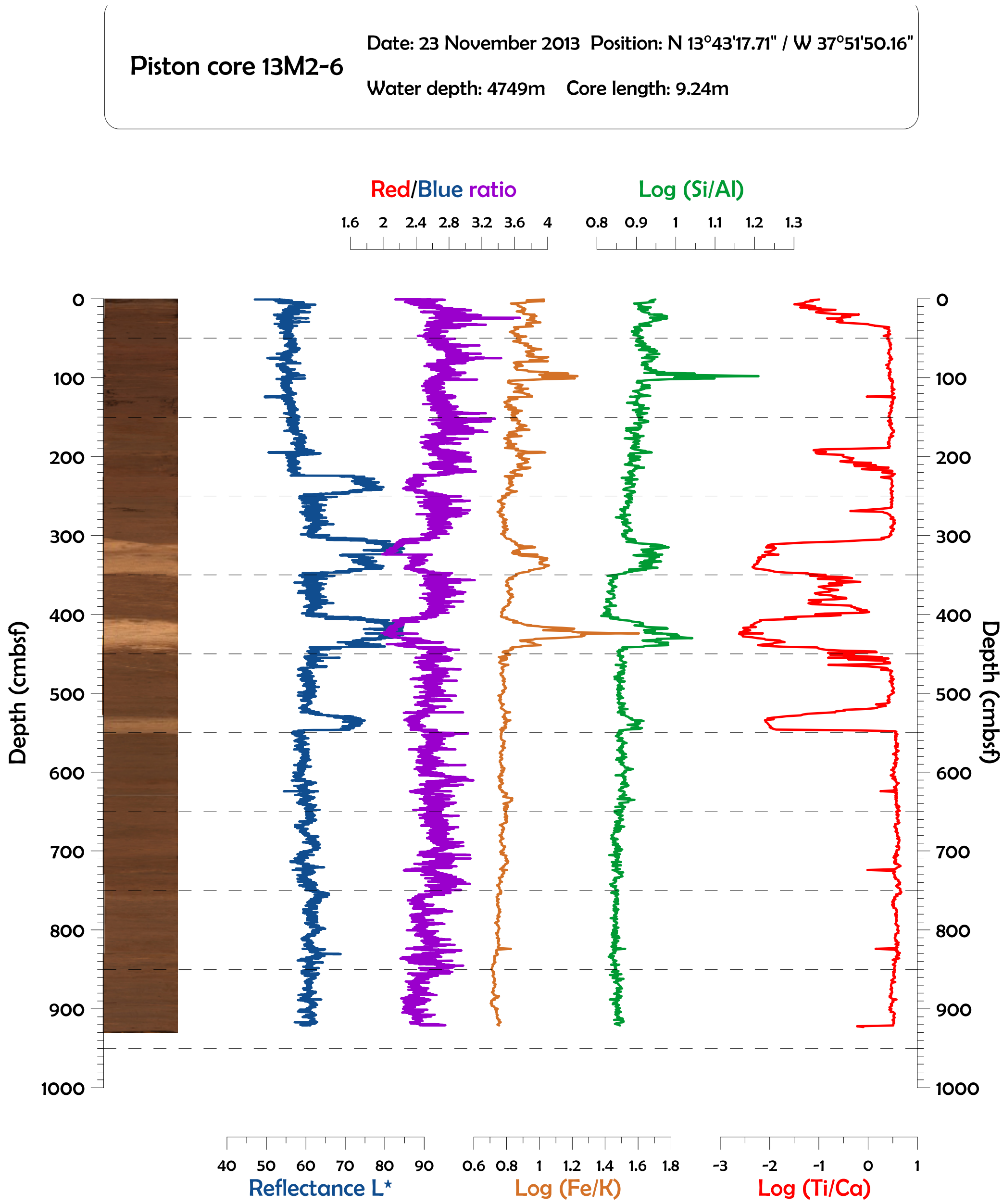


Figure 5.4.4: The line scan, Reflectance l and Red/Blue ratio derived from the line scan and the Log (Fe/K), Log (Si/Al) and Log (Ti/Ca) ratio derived from the XRF scan, of piston core 13-M2-6. 3 lighter bands, rich in Calcium are present in a further fairly homogeneous core.*

At station M4, cast 6, a piston core sample of 7.21 meters was retrieved from a depth of 5048 meters (figure 5.4.6). After crossing the mid-Atlantic ridge, the influence of the Amazon becomes notable: sandy layers appear in the sediment. Light scanning of these parts of the core was only possible after sucking up the excessive water, causing a shimmering image, with kitchen paper.

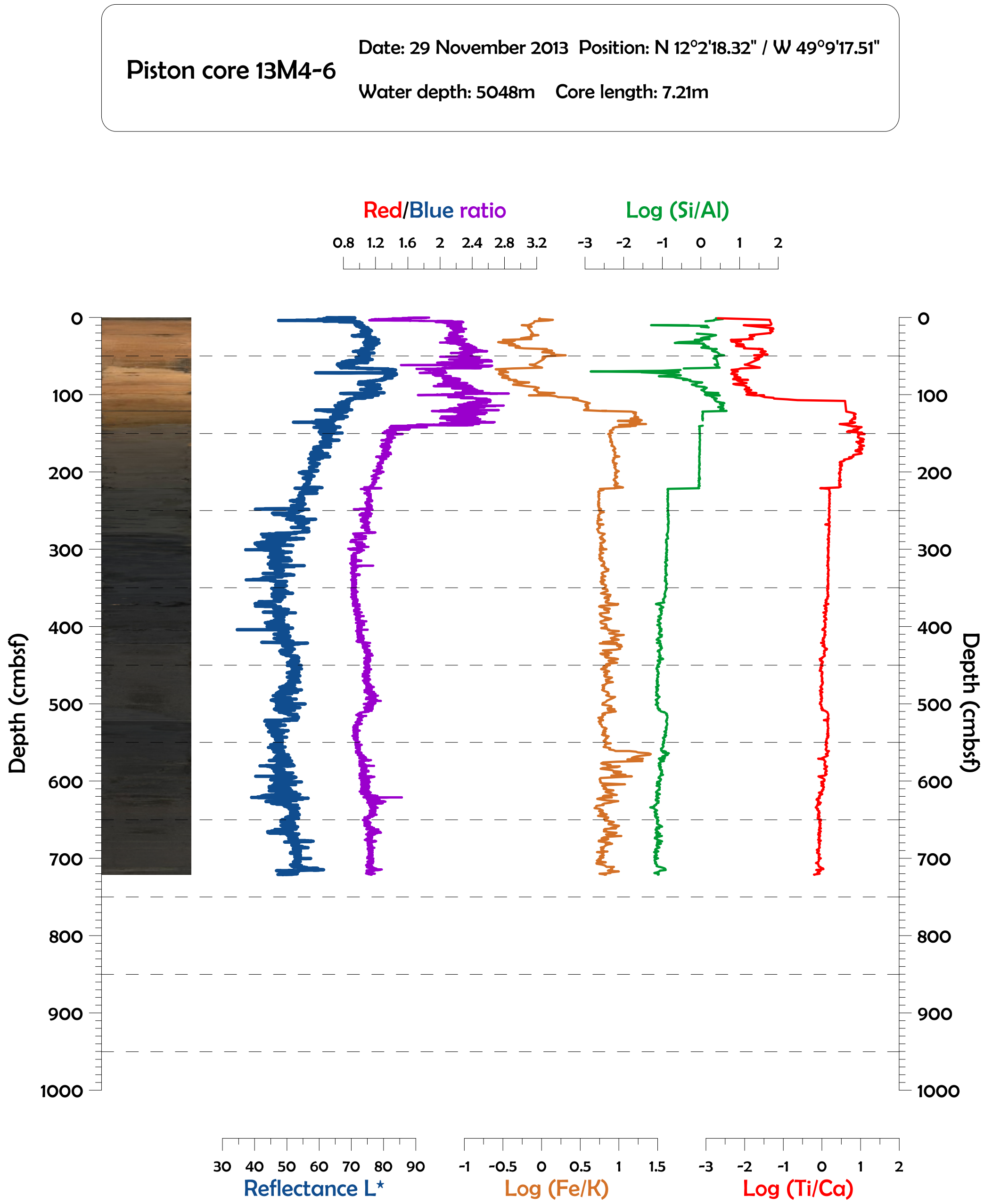


Figure 5.4.6: The line scan, reflectance l and Red/Blue ratio derived from the line scan and the Log (Fe/K), Log (Si/Al) and Log (Ti/Ca) ratios derived from the XRF scan of piston core 13-M4-6. The top 100 cmbsf show yellowisch fine-grained material with an unconformity around 50 cmbsf. The dark lower part contains sandy layers and organic material, even little straw like features.*

At station M5, cast 5, a piston core sample of 4.89 metres was retrieved from a depth of 4621 metres (Fig. 5.4.7). We see even more influence of the Amazon in this last piston core by the presence of organic material and sandy layers, presumably originating from turbidites that disturbed the sedimentary signal. The high water content of the sandy layers probably caused problems with the XRF counts of the lighter 10 KeV elements. Especially the silica counts turned out to be lower resulting in unexpected values. This requires further analysis.

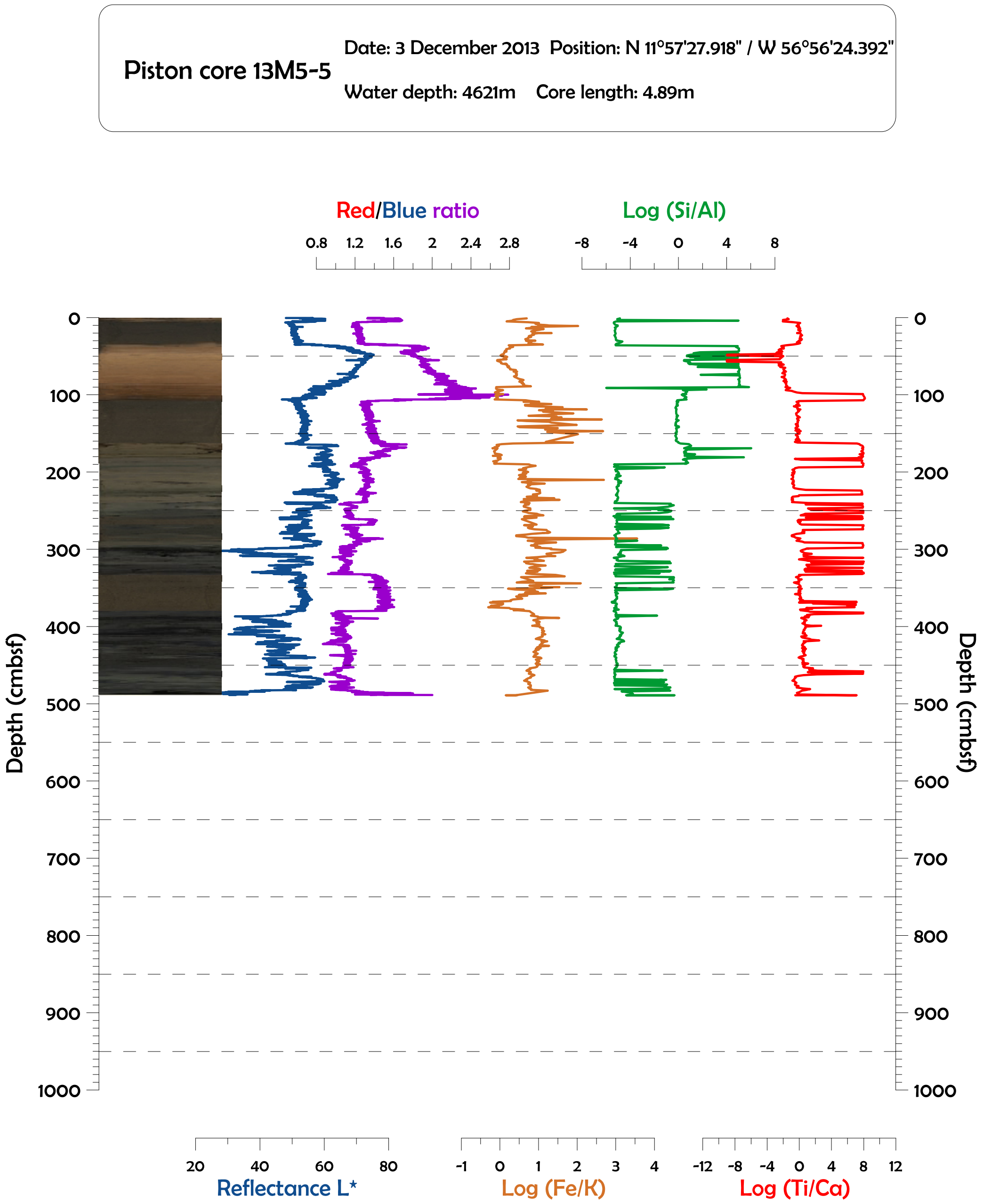


Figure 5.4.5: The line scan, Reflectance l and Red/Blue ratio derived from the line scan and the Log (Fe/K), Log (Si/Al) and Log (Ti/Ca) ratios derived from the XRF scan. The top part is formed of lighter clayish sediments, the lower part contains sandy layers that form erosion surfaces with the more fine grained material.*

5.5 *Plankton sampling and multinet*

5.5.1 *Multinet*

Michael Siccha & Brett Metcalfe

The planktonic community is dynamic, changing both through time and space, sampling of which is further inconvenienced by the complexity of their environment. Different species and different growth stages of the same species of planktonic foraminifera are known to inhabit different depths in the water column. One attempt to overcome this is the use of a multiple opening and closing net system towed obliquely behind a ship that enables sampling at distinct levels in the water column. Oblique, rather than vertical, towing allows for a larger amount of plankton to be sampled at a given interval or at greater depth resolution.

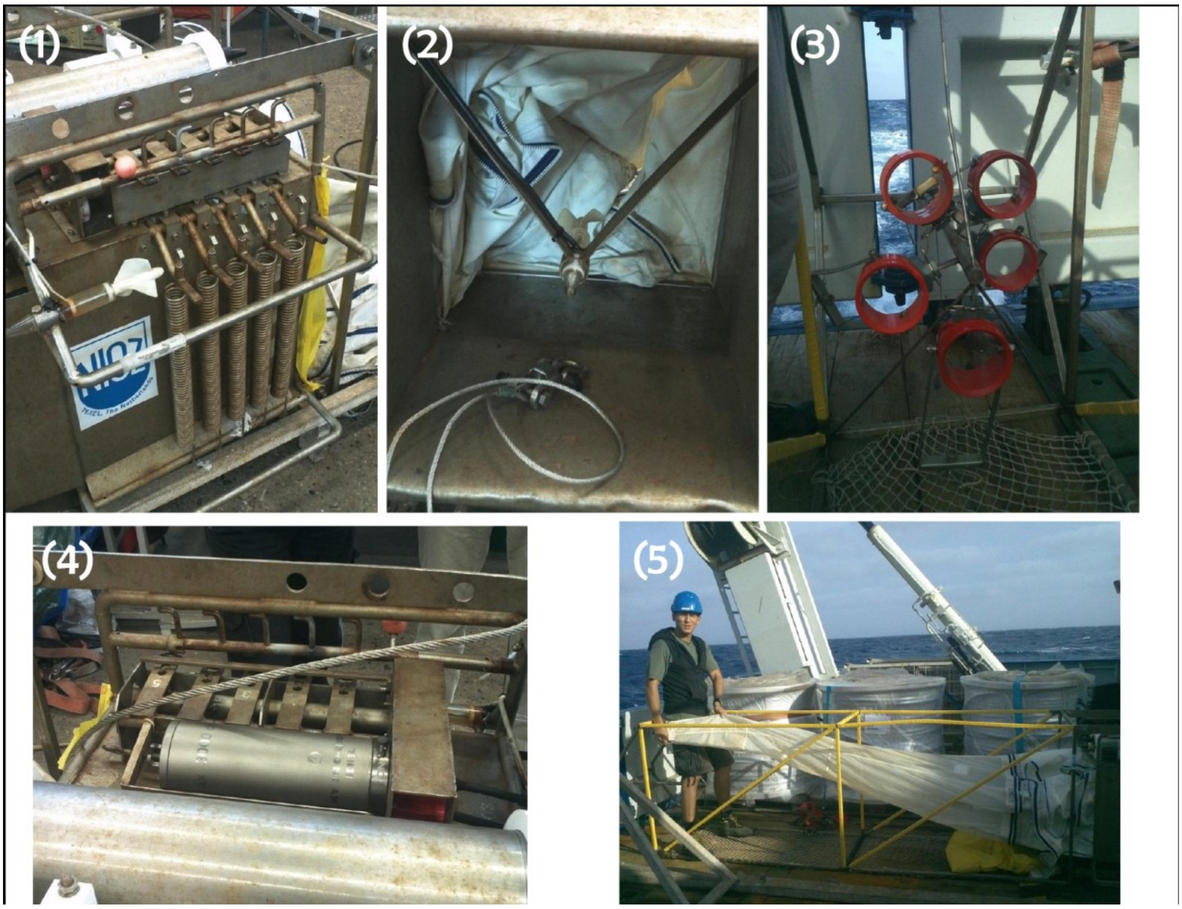


Figure 5.5.1: (1) Stainless steel net frame with pressure capsuled motor unit attached to springs which open and close the net. Also visible is the external flowmeter. (2) View of the zip fasteners and internal flowmeter. (3) Net bucket holders, in a clockwise direction from bottom are associated with nets 1 to 5. (4) Top view of pressure capsule motor unit and springs. (5) Net surrounded by steel frame which is taped to ensure against wearing and tearing of the nets.

The HydroBios Multi plankton sampler MPS90 ('Multinet') consists of 4 open and closing nets and a final 5th net (50 x 50 cm opening) that remains open until retrieval. These are attached via zip fasteners to the stainless steel Multinet body. The Multinet has been customized by the technical department of the NIOZ and holds in addition to the motor unit for opening and closing the nets, two flowmeters (one internal and one on the exterior) as well as a pressure and a temperature sensor. The two flowmeters are mounted with one in the center of the body inlet to measure the volume of filtered water and the other outside to detect a clogging of the plankton net by a large divergence in measured flow. At the time of sampling no recent calibration of the used flowmeters was available, so the default values for the conversion of revolution counts into flow rates given by the plankton net control software were employed. Before net deployment it would be necessary to have performed a proper calibration of the flowmeters, e.g. flow flume (NIOZ-Yerseke). The nets, attached with individual cod-ends, have a mesh size of 100 µm and are housed within a metal framework to prevent entanglement and damage within and out of the water. At the end of each net is a net bucket that collects the sample with a 100 µm mesh (recycled from damaged nets) that is positioned so that the mesh faces downwards allowing water to flow out. To ensure a horizontal position of the plankton net in the water during sampling, a V-Fin depressor was attached below the front of the body inlet and a buoyancy body (in this instance a plastic crate on a rope of a few meters) at the end of the steel cage. The Multinet is connected to the ship via a single conductor cable that allows for data transmission to a deck unit allowing for specific sample intervals to be selected. Opening and closing of the nets is done via an arrangement of spring-charged levers that are released by a motor unit, which is activated via the attached deck unit.

Table 5.5.1: Calibration factors used in the NIOZ multinet software.

	Factor	Offset / Area
Depth	1.0335	0
Temperature	22.936118	-1.6777137
Volume	0.2666667	0.25z

After the recovery of the mooring at station M1 a SeaBird 37SM MicroCAT CTD (S/N 37SM64011-8511) became available for use in conjunction with the plankton net. This CTD was mounted next to the already present pressure and temperature sensor and used since Station M2 in data-logging mode with a sampling interval of 6 seconds, recording depth, temperature and salinity. Since the Seabird CTD had been calibrated by the manufactures just before its deployment with the mooring one year ago, the plankton net sensor calibrations were adjusted to match the parameter values measured by the CTD. Optimum fit of the pressure data between the two instruments was difficult to determine, as the raw output of the pressure sensor of the net gives a value zero for atmospheric pressure above the sea surface. An optimum fit of the pressure calibration for deep casts suggested an depth factor of 1.043 and an offset value of 7.5, which would have meant to disregard a large number of measured values for the shallower casts and was thus not used. The calibration factors for calculation of the integrated values for the individual nets and the binned data used in the figures are given in table 5.5.1. An overall difference between sensors (calculated as RMSE) of 3.36 m for maximum depth and 0.30 °C for temperature (binned data for both up- and downcast) has been calculated for the available 4 casts. The divergence of measurements is largest during the upcast, as can be seen in the plots, and causes a significant difference in determination of mixed layer depth. The user of the data is advised to revisit the raw data and determine his own calibration or to preferentially use the SBE 37 MicroCAT or SBE19 CTD data, where available.

Two casts were performed at stations (where time allowed), a shallow cast with depth intervals of: 150-100 m, 100-75 m, 75-50 m, 50-25 m and 25 m-deck and a deep cast with depth intervals of: 800-500 m, 500-300 m, 300-200 m, 200-150 m and 150 m-deck. Shallow casts (<150 m) take approximately 45-60 minutes using a winch speed of 6 meters/minute whereas deeper casts (< 800m) take approximately 180 minutes. For plankton net sampling the Pelagia's speed was reduced to 2 knots or lower. The plankton net was lowered through the water column to the lower end of the deepest sampling interval with a winch speed of 30 m/min; hoisting was done with winch speeds between 6 m/min to 20 m/min depending on the depth, plankton density and the ship’s speed.

At the end of each sampling and before the retrieval of the samples in the net cups, the plankton net was positioned in an acute angle on the aft deck of the ship and washed from the outside with sea water. This ensured the transfer of most of the plankton that is clinging to the inside of the nets into the net cups. Especially the manoeuvre of bringing the plankton net out of the water and onto the aft deck of the ship can cause the spill of sampled material from the net cups back into the nets. Only after this washing procedure were the sample cups dismounted and brought into the laboratory. Each sample was transferred from its cup onto a 65 μm sieve with the help of filtered seawater, where particular attention was given to collect all plankton from the net cloth of the cups. The sample was consequently washed with deionized water in the sieve to remove the salt, transferred in a plastic bag and deep frozen at -80 °C. Between plankton net deployments the net cups were carefully cleaned with fresh water and between deployments at different station also the plankton nets themselves were hosed with fresh water to reduce the risk of sample contamination. At two stations (M4 and M5) where a low salinity lens occurred water was collected from the CTD bottles for isotopic analysis.

Figure 5.5.2: The multinet in washing position

5.5.2 *Lugol experiment* — *Michael Siccha*

Preservation of samples for later analysis is problematic in general because of the long time periods between collecting samples and having then returned to the sampler. The NIOZ-VUA currently utilise the freezing method described above as this has the least impact on the sample in terms of shell material. However, for organic material freezing has the potential to impact the cytoplasm and symbionts. Researchers focusing on algae utilise Lugol solution (KI + I_2 dissolved in pure water) to fix the organic material. A number of foraminiferal specimens from the fifth net of the Teststation deployment, which whilst torn had enough specimens for analytical purposes, were wet picked into this solution for later analysis.

Problems

The fifth net failed twice due to tearing of the net requiring replacement. The first time the net ripped along the side which allowed some material to remain within the net, the second time (the replacement net) the net was sheared clean off the cod-end and thus no sample was collected. A shallow cast was not performed at the third deployment due to time constraints. During this deployment the internal flowmeter broke and was replaced despite appearing undamaged. Throughout the deployments the Multinet would on occasion stop at a single depth for up to 10-15 minutes. This is likely a play between the amount of cable slack (500m water depth is approximately 700m of cable spooled out), currents and flow of water around the net. This may have an effect on the evenness of sampling along the vertical gradient as the flowmeters continued to show movement of water through the net.

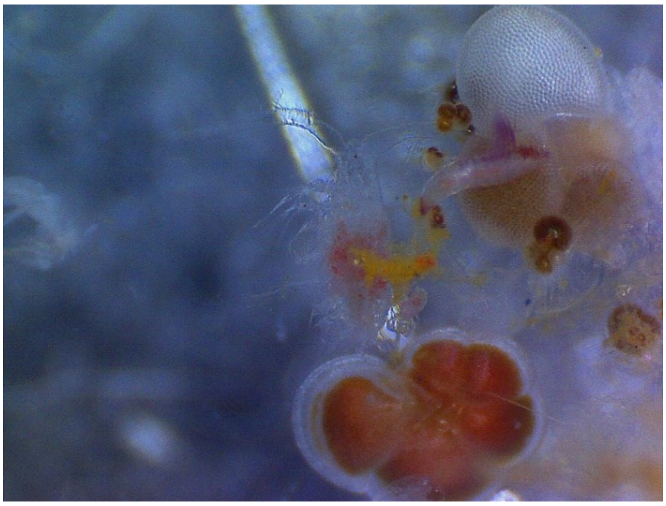


Figure 5.5.3: USB microscope image of the planktonic foraminifera G. sacculifer *and* G. menardii, *between them is a translucent copepod. Sample 37 collected between 18.58-06.51 (13°01.692 N 32°30.641 W to 13°20.066 N 34°42.300 W)*

5.5.3 *Plankton pump sampling* — *Brett Metcalfe*

The deployment, operation and retrieval of multinet sampling is a time-consuming task (4-5 hours depending on conditions) that requires a long period of time of sailing at a reduced speed (<2 knots) increasing transit time. One approach to increase sampling without adversely affecting ship duties and which is weather and time independent is to sample using the shipboard fire and deckwash pumps. The limitation being that whilst these samples have a large spatial extent they only cover at best the upper 5 meters of the water column, and thus their use in ontogenetic (life history) studies, i.e. depth migration in plankton foraminifera, is not possible. Previous studies, i.e. Ufkes (2000) and Ottens (1998), have shown that they can be used as a first order approximation of the complexity and diversity of the surface to intermediate water depth communities of foraminifera. Furthermore they can provide a large sample set for use in both $\delta^{18}O$-temperature calibrations (Ganssen, 1984) and assessing the influence of surface nutrients (i.e. phosphate, nitrate) and carbonate chemistry ($[CO_3^{2-}]$) (Aldridge et al., 2011) when used in conjunction with other sampling (e.g. water for isotope and nutrient analysis).

The plankton pump was situated on the aft-deck of the R/V Pelagia and consists of a fire hose connected to a flowmeter and a 100 μm net with attached cod-end (Figure. 5.5.4). The exchangeable net bucket is cleaned of sample material using filtered seawater rinsed with de-ionised (MilliQ) water over a 63μm sieve and frozen at -80°C.

The rinsing step is required to prevent brine formation during freezing of the sample. Between exchanging net buckets the net was hosed down to prevent contamination and build-up of potential flow-blocking material. Volume was noted down and later converted to m3 per minute. Hydrographic parameters such as temperature, salinity and seawater density were measured using the ship's Seabird SBE21 thermosalinometer. This data was only available after the 17th November. However, there is an apparent offset between salinity measurements taken using the CTD and this system.

Figure 5.5.4: setup of the plankton pump. The deckwash (red hose) pumps water through the net and flow meter.

During cruise 64PE378 Traffic-II over 90 plankton pump samples were taken from the 11th November to 6th December in approximately four 6 hour intervals: 00.00-06.00, 06.00-12.00, 12.00-18.00 and 18.00-00.00. Given the nature of this sampling methodology during busy periods on the aft-deck (i.e. buoy mooring deployment) sampling time could be reduced or extended as permitted. Water for isotopic analysis was collected using the same hose at the end of one sample interval, samples are thus labelled for the preceding sample. Samples that have associated water samples are: 16, 20, 21, 22, 23, 24, 50a, 50b, 51, 52a, 52b, 53, 57, 64, 72, 73, 77, 79, 80-end of sampling.

A number of samples were split, using a Folsom plankton splitter, to check the diversity and abundance of foraminifera within the samples as well as to test the use of different mediums in sample preservation and transportation (see below for further details). A quick observation shows the presence of crabs, pteropods, foraminifera and copepods as well as other marine life. The presence of crabs and gastropods is a curiosity given the distance from the continental shelf. Several times the Sargasso weed was seen from the deck. These were fished out independently of the samples using a net and frozen for later analysis of the community. However, preliminary observations reveal that these provide a microenvironment for a diverse ecosystem consisting of bryozoa, gastropods, shrimps, swimming crabs and calcifying worms.

5.5.4 *Ethanol preservation experiment* — *Brett Metcalfe*

Since the early 80's various (former- and current) members of the Earth and Climate Cluster of the VU University Amsterdam have collected plankton pump samples during different cruises to different ocean basins. The result of which is a vast resource for foraminiferal analysis that covers the North Atlantic, South Atlantic, Mediterranean, Red Sea, Indian Ocean and the coastal waters around Indonesia. Early cruises preserved the samples in a seawater-alcohol/ethanol (98%) mixture for the journey back to Amsterdam.
Since 2000, NIOZ introduced the freezing methodology outlined above as a better way of keeping both shell and cytoplasm intact. Recent analysis of the material collected during the Snellius II expedition (1984 and 1985), both G0 and G5 cruise tracks, has shown transluscent pteropods and foraminifera with spines despite these bottles having a pH of 4.0 to 7.0 counter intuitive to what should be expected.
Samples 28 (12°13.981 N 25°32.651 W to 12°23.160 N 26°30.162 W; 12.12-18.35 Shiptime) and 51 were split to act as a modern comparison. The sample was washed over a 63 μm sieve to concentrate organic material, split three times to get 1/8 and 7/8 splits. The larger proportion

was processed like an ordinary sample. The smaller split was poured into a 50ml bottle, and topped up with seawater to get 15ml. The pH was measured using indicator strips to be 8.0 pH units (average modern seawater is 8.2 pH units). Ethanol (30ml) was then added (giving a total sample amount of 45ml), shaken and then pH was measured. An initial value of 6.0 pH units was measured. Within 1-3 minutes all plankton was dead and after 25 minutes a milky layer (approx. 10ml) had formed at the bottom of the sample container just above the remnants of the plankton material. The sample was then left in the dry lab. outside of the fridge to better replicate the original sampling methodology. On return to Amsterdam the carbonate chemistry will be measured using a Titration Manager.

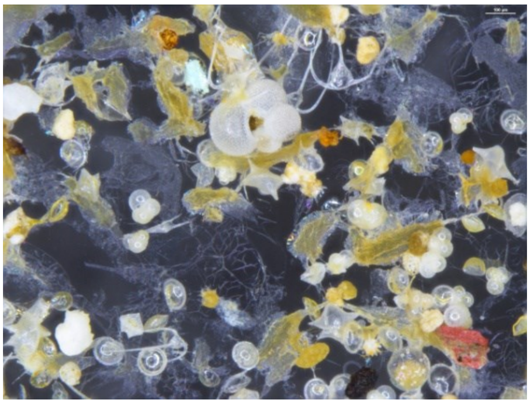


Figure 5.5.5: Light microscope image of P33-G0 with a pH of 5.8 collected in 1985 and stored in ethanol outside of a fridge for the past 28 years with foraminifera still intact.

Problems

The ship's Seabird SBE21 thermosalinometer was first available after the 17th November. However, after it was turned on an apparent offset between salinity measurements taken using the CTD and this system was noticed. The Seabird utilises conductivity and temperature to calculate salinity. However, the conductivity sensor above 25°C only gave a constant value and thus salinity fluctuated only as a function of temperature. It would be advisable to have the thermosalinometer calibrated prior to departure. Furthermore the position of the pump sample on the aft deck made it inaccessible during deployment of moorings, in future it may be better to use the pump located next to the wet laboratory although this may be in the way during piston and multicoring as well as during CTD sampling. Finally on more than one occasion the net bucket mesh would clog which would increase the time taken to exchange the net buckets. In one instance we sampled what appears to be fish eggs that clogged the net. It was at this point that we learned that the spare (replacement) net was torn leading, to a two hour delay between sampling end and start.

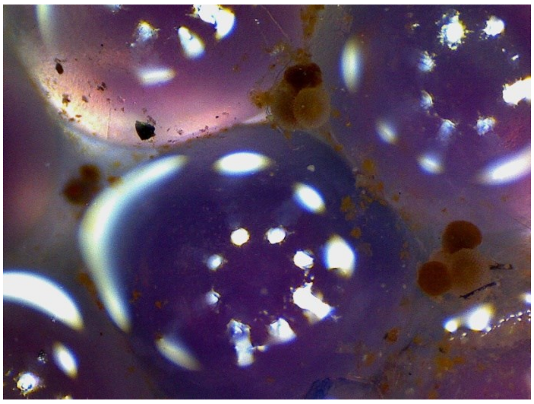


Figure 5.5.6: Microscopic image of sample filled with fish eggs, there are planktonic foraminifera within the sample. The specimen on the right a 'twin' was removed and fixed with Lugol solution for later genetic analysis.

5.6 *Secchi disk*

Ronald Veldhuizen

Water clarity and colour are related to its biological and chemical qualities. For instance, chlorophyll concentrations are tightly correlated with water clarity (Rast and Lee, 1978). A popular assessment tool for this is the Secchi disk. Developed by Italian astronomer Pietro Angelo Secchi SJ in 1865, the Secchi disk has been around for a long time and thus makes historical comparisons consistent. It is also known for its relative ease of use: a bright white disk is lowered into the water column and the depth at which is only just visible, is noted. This depth is called the Secchi depth.

With the aim of doing water clarity and colour measurements at research stations located along this transatlantic route, we used a Secchi disk provided by Marcel Wernand from the NIOZ. Forel-Ule scales for assessing water colour were also provided on his courtesy. The colour can be assessed by first measuring the Secchi depth, pulling up the white disk to half that depth and compare the disk colour with that on the Forel-Ule scale. A second goal was to test two separate smartphone applications which aid in performing these two assessments: the Secchi app and the CITCLOPS app, which both run on Android operating systems. A Samsung Galaxy camera that runs both these applications was also provided by Wernand.

The original plan was to mount the Secchi disk on the CTD and measure the exact length before it disappeared, but unfortunately all CTDs on this particular cruise took place during the dark.

Preliminary results

On the 9th of November, we performed a test assessment in the harbour of Las Palmas de Gran Canaria. The Secchi depth was 4.2 meters. The Forel-Ule scale was noted by the CITCLOPS application and automatically sent to a central database via the internet. The water temperature was 22.8° Celsius.

On the 11th of November, we did the first Secchi disk assessment in the open ocean. The Secchi disk unfortunately disappeared under the ship. The deepest point at which we could still see it turned out to be 17 meters. The water had a colour code of 4 on the Forel-Ule scale and appeared to be clear and blue.

On the next day, the 12th of November at 9.30, we decided to re-do the test on a different side of the ship. Again the disk slid under the ship, but the assessment turned out drastically different: we noted a Secchi depth of 24.3 meters. The Forel-Ule scale was consistent with the day before, coming out as 4. Unfortunately, the colour assessment with the CITCLOPS app was impossible to do with the Samsung Galaxy camera. On the LCD screen of that camera the disk was invisible due to waves and reflecting sunlight, and so we could not pick the right colour bar. The Secchi app functioned up to specifications.

We tried another Secchi disk assessment at station M1 on November the 16th. Again , the CTD took place in the dark, so the disk could not be simultaneously launched. We therefore did the measurement by hand again. This time we could not note any depth at all: the disk slid under the ship. The sailors warned us that the rope might entangle with the ship's propeller.

On November the 20th 9:56 UTC, at station M1a, we performed a new assessment by hand. This was a relatively calm day with only some small waves. The Secchi disk submerged well, only disappearing under the ship a few times. It was hard to make out whether the disk stopped being visible due to a limit in water clarity, or due refraction and reflection of light in the waves. We noted a Secchi depth of 27.8 meters and concluded that the water colour scored a 3 on the Forel-Ule scale. The air temperature was 25.4° Celsius while the water temperature was 27.8° Celsius. Disappointingly, the Secchi app on the Samsung Galaxy camera crashed repeatedly while entering these data.

At station M2, where we arrived at November the 22nd, the Secchi disk failed at 10:17 UTC. The seas were calm enough and the Secchi did drop down to a considerable depth, but we were out of rope before the disk disappeared out of vision. The maximum depth we could note was 30 meters, but the real Secchi depth was probably more than that. We decided that without a proper Secchi depth assessment, there could be no valid Forel-Ule scale assessment, so we skipped that.

The seas were too rough at station M3 on the 24th of November to perform any valid Secchi depth assessment. The disc submerged, but the currents immediately carried it away from the ship, stretching the rope horizontally. We decided not to assess Secchi depth as long as the waves were too high.

We arrived at station M4 on the 28th of November, but again the wind was too strong and the waves were too high. Another attempt was done on the 29th of November, but the disk was pulled under the ship again. To avoid propeller damage, we cancelled the assessment. No further attempts were made during the cruise.

Our recommendations for future attempts are as follows. The rope should be longer and, if possible, be marked with a coloured and clearly visible centimetre scale. The disk itself should be heavier and preferably larger: it is now too easily carried away by the current and when in deeper waters it pops easily out of vision due to light distortions on the surface.

Furthermore, the Secchi app could be improved. Obviously, it should not crash. The interface would be more user-friendly if the app keeps a visible log of past data entries, which it currently does not. The CITCLOPS app which provides Forel-Ule scales on the camera screen also doesn't keep a visible log. Moreover, the CITCLOPS app requires the user to look for a submerged Secchi disk on an LCD screen. In the tropics, this is almost impossible to do and a subpar method compared to using the naked eye and a real-life Forel-Ule scale. Even in the shade, the contrast of the Samsung Galaxy camera proved too low to spot the Secchi disk while using the CITCLOPS app.

Figure 5.6.1: Brett and Ronald (left) operating the Secchi disk, which is clearly visible in the bright blue open-ocean waters (right)

Reference

Rast, W. and G. F. Lee. 1978. Summary analysis of the North American (US Portion) OECD eutrophication project: nutrient loading-lake response relationships and trophic state indices., EPA 600/3-78-008, US EPA, Corvallis, OR.

5.7 *Mooring recoveries*

Geert-Jan Brummer, Michèlle van der Does and Laura Korte

5.7.1 Overview moorings 2012-2013

One of the major goals of this cruise was the recovery, servicing and redeployment of long-term moorings at a transect across the equatorial North Atlantic Ocean, at 12°N. These sub-surface moorings are deployed for a period of 3 years, starting in October 2012 and serviced each year. Five moorings are equipped with ADCPs, current meters and T-S sensors, and two sediment traps each at a nominal depth of 1200 and 3500 meters (see table 5.7.1 for details). The measuring interval of the physical instruments ranges from 5 minutes (T-S sensors), 15 minutes (current meters, OBS) to 30 minutes (ADCPs, see table 5.7.2 for details on the sensors).

The moorings of M1-M5 were originally deployed during RV Meteor expedition M89 in October 2012, and the moorings were equipped with two Technicap PPS-5/2 sediment traps, one at 1200 m depth, the other at 3500 m, each with a collecting area of 1.0 m^2 and provided with a 1 cm^2 honeycomb baffle. The Technicap model PPS 5/2 sediment traps consist of a funnel, carrousel and motor-unit. Their pre-programmed sampling intervals were 16 days for each of the 24 collecting cups on both traps, starting on October 19, 2012 at 12:00 UTC, thus ending on November 7 2013, 12:00 UTC.

Please see more information in the moorings' detailed drawings in Annex I.

Table 5.7.1. detailed information on the sediment-trap components (BC = Bar Code)

Mooring	Trap depth	Motor unit	BC	Funnel	BC	Carrousel BC
M1	1150m	3-230	1212	91.3	8501	43250
	3400m	9-205	9447	62	8495	43427
M2	1200m	3-325	9782	84	43434	43311
	3500m	29	7238	45	43465	43281
M3	1300m	3-236	9768	91.3	9836	43168
	3540m	9-263	34982	53	9942	43229
M4	1130m	9-265	35354	46	8488	1250
	3370m	2-212	9614	53	9942	43199
M5	1280m	7-243	41430	87	43342	55963
	3520m	9-264	34968	86	43373	56083

5.7.2 Sample recovery

Upon arrival on deck, the entire carrousel with sample bottles was dismounted from each trap, and transferred to the cold room for dark storage at 4°C. Prior to deployment the sample cups had been filled with seawater collected at the deployment depth of each trap and from the actual deployment site, to which a biocide ($HgCl_2$; end-concentration 1.29 g L^{-1}) and a pH-buffer ($Na_2B_4O_7{\cdot}10H_2O$; end concentration 1.29 g L^{-1}) had been added to a density slightly in excess of the ambient seawater.

As part of the shipboard processing protocol, the sample carrousel was put on top of a stable stand for safe manual rotation of the carrousel and collection of any unwanted leakage of the poisonous supernatant solution. The carrousel was manually rotated to the first sample position to remove the top 30 ml of supernatant solution from the connecting neck with an all-PP syringe. About 15 mL of Milli-Q water was used twice to flush the syringe and the attached tube, followed by 5 mL of the supernatant solution to flush a syringe-top 0.2 μm Acrodisc® filter. About 5 mL of the supernatant solution was used to fill a PE-pony vial for shipboard analysis of silica, phosphate and ammonia. The remaining 20 mL was transferred to a 30 ml ZPE bottle for subsequent analysis of pH. This procedure was repeated until the supernatant solution was removed from the connecting neck above each of the 24 sample positions for both trap carrousels, so that all sample bottles could safely be removed from the carrousel, capped, and stored.

Table 5.7.2. Detailed information on the moorings' sensors

Station	Depth	Instrument	S/N	BC	Start
M1	750	ADCP	3552	2875	8 Oct
	1140	Seacat CTD	2667	10856	8 Oct
	1150	Data logger FLNTU	B7 2774	7252 74575	8 Oct
	3380	RCM	406	703	8 Oct
	3390	Seacat CTD	4352	12775	8 Oct
	3400	Data logger Seapoint	BC 11098	1199 27748	8 Oct
	4980	RCM	414	758	8 Oct
M2	835	ADCP	3616	2905	10 Oct
	1225	Seacat CTD	4345	12805	10 Oct
	1235	Data logger FLNTU	B9 2773	9584 74599	10 Oct
	3470	RCM	193	1946	10 Oct
	3480	Seacat CTD	3622	1649	10 Oct
	3490	Data logger SeaPoint	C3 11908	9546 41508	10 Oct
	4770	RCM	44	2363	10 Oct
M3	890	ADCP	5945	5203	12 Oct
	1290	Seacat CTD	3624	1656	12 Oct
	1300	Data logger FLNTU	BA 2737	27908 74582	12 Oct
	3520	RCM	415	30021	12 Oct
	3530	Seacat CTD	2672	30021	12 Oct
	3540	Data logger SeaPoint	BB 11104	1205 22545	12 Oct
	4620	RCM	405	727	12 Oct

Station	Depth	Instrument	S/N	BC	Start
M4	720	ADCP	6778	5302	13 Oct
	1120	Seacat CTD	6274	32445	13 Oct
	1130m	Data logger FLNTU	B1 2855	12171 74551	13 Oct
	3350	RCM	48	1861	13 Oct
	3360	Seacat CTD	2657	3803	13 Oct
	3370m	Data logger SeaPoint	C4 11421	9522 25027	13 Oct
	4650	RCM	242	11150	13 Oct
M5	870	ADCP	3514	888	19 Oct
	1270	Seacat CTD	8512	38706	19 Oct
	1280m	Data logger FLNTU	A3 2859	6101 74568	19 Oct
	3500	RCM	190	1816	19 Oct
	3510	Seacat CTD	8513	38720	19 Oct
	3520m	Data logger SeaPoint	C6 11099	35330 22538	19 Oct
	4380	RCM	187	1809	19 Oct

For a first order estimate of the mass flux, the height of the residue in the collecting bottles was measured to the next millimeter and converted into residue volumes using a calibration curve (Fig. 5.7.1).

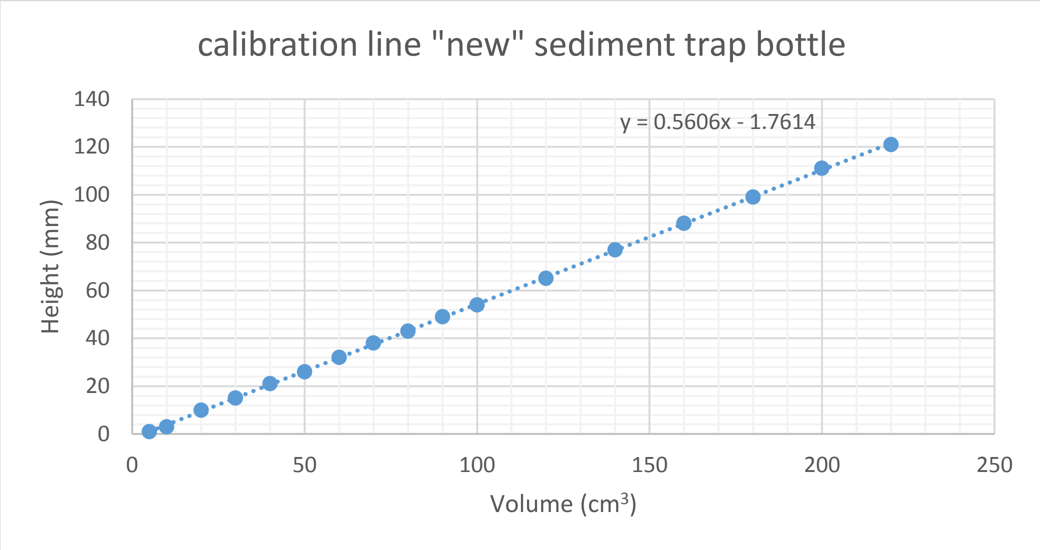


Figure 5.7.1. Calibration line to express the volume of samples in the PPS traps.

5.7.3 Preliminary Results

In general the instruments that were recovered worked well. Collecting efficiencies of sediment traps are strongly affected by the (changing) tilt of the sediment trap during their deployment and the (changing) current velocities at depth. In order to determine these parameters, each sediment trap was equipped with a sensor package that recorded tilt in two perpendicular directions and pressure. Current velocities were measured using a downward-looking ADCP mounted in the floatation body 400m above the upper sediment trap and a current meter 16m above the lower sediment trap in each of the five moorings. In general, tilt measurements and temperature-pressure data indicate that the moorings remained effectively vertical during the deployment period.

A preliminary characterisation of the magnitude and temporal variability of the particle fluxes settling into the sediment traps can be deduced from the residue volume in the collecting cups and the concentration of dissolved silica and phosphate. Particularly impressive were the two flux peaks in 13M4 that appear in the same bottles (i.e. 12 and 24) at both 1200m and 3500m.

All releasers on the trap moorings responded immediately upon the acoustic wake-up calls. All traps lacked an O-ring on the zero-position, thus a free space between the funnel and the connecting neck existed. As a result, each collecting cup rotating below the funnel leaked the supernatant solution from the connecting neck ("headspace"), and promoted exchange from the collecting cup itself directly with the ambient seawater rather than the funnel. This may well have reduced the collecting efficiency of the traps as incoming particulate matter through the funnel may escape through the free space between funnel and connecting neck. Most probably, it will be responsible for the "insufficient poisoning" that led to decay of the collected material inside the cups (as indicated by very high ammonia and phosphate concentrations, bad overall smell and occasional discoloration of the supernatant solution), producing dangerously low pH (promoting carbonate dissolution) and promoting bacterial productivity. Following recognition of this problem after recovery of the first mooring (M1), an O-ring (red, thick) was mounted on the connecting neck that should provide a robust seal. We expect better preserved material following next year recoveries.

Mooring 13M1

We lost sediment trap 13M1-L because the titanium bar broke inside the trap, which also led to the loss of all instrumentation below the lower trap including the release gears (see Annex IV for a complete list of all lost equipment). Sediment trap 13M1-U was successfully recovered and had performed well.
Since pH values were uncomfortably low (down to 6.8 in 13M1-U24) and ammonia concentrations very high (over 1.5 mM in three cups, Fig. 5.7.2), it was decided to post-poison all cups and increase their pH. In order to prevent further decay, post-poisoning was carried out by adding 10ml of a 18.75g/L solution of $HgCl_2$ in Milli-Q after pipetting 20ml from the supernatant solution. Subsequently, five drops (about 0.25ml) of a 80g/l solution of NaOH in milliQ was added, increasing the pH by about 0.5 pH units.
All connecting neck supernatant (30 ml) leaked from one cup (13M1-U1) while the others seemed OK.

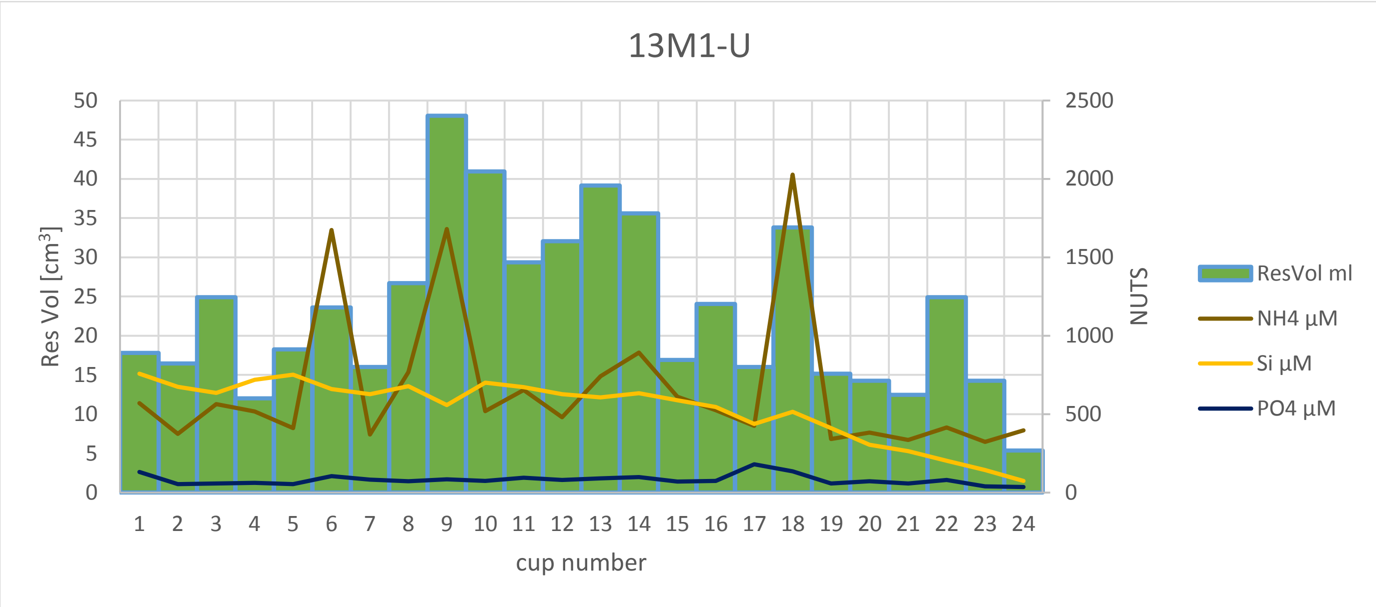


Figure 5.7.2. 13M1 upper sediment trap estimated mass flux and nutrients

Mooring 13M2

Mooring 13M2 was successfully recovered, including both traps, which had both performed flawlessly. Values for pH ranged from 7.9 (13M2-L5) to 8.6 in the lower trap (13M2-L24) and were significantly higher than for the upper trap, which ranged from 7.4 to 8.7 with most in the middle 7 ranges. A few samples were smelly and/or discoloured in the upper trap (13M2-U) and although pH values were undesirably low, it was decided not to post-poison the samples. The nutrient analyses show low values for both traps, except for two cups where the ammonium values exceed 1.4 mM (Fig. 5.7.3 & Fig 5.7.4).

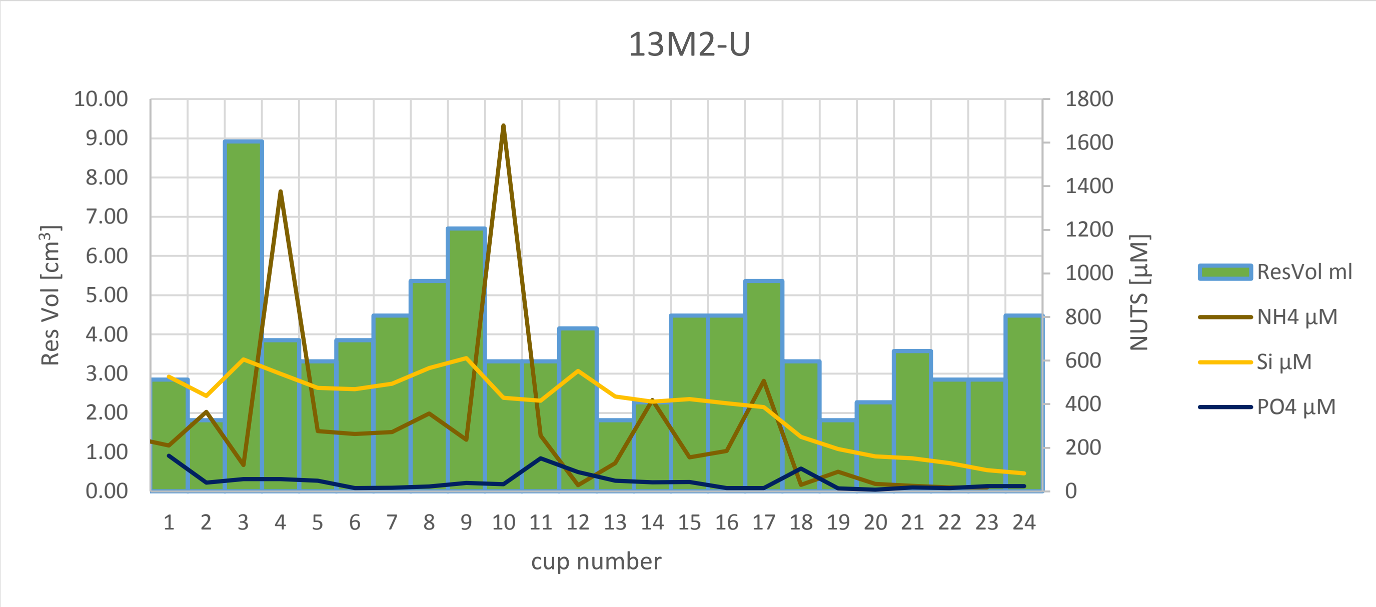


Fig. 5.7.3. 13M2 upper sediment trap estimated mass fluxes and nutrients

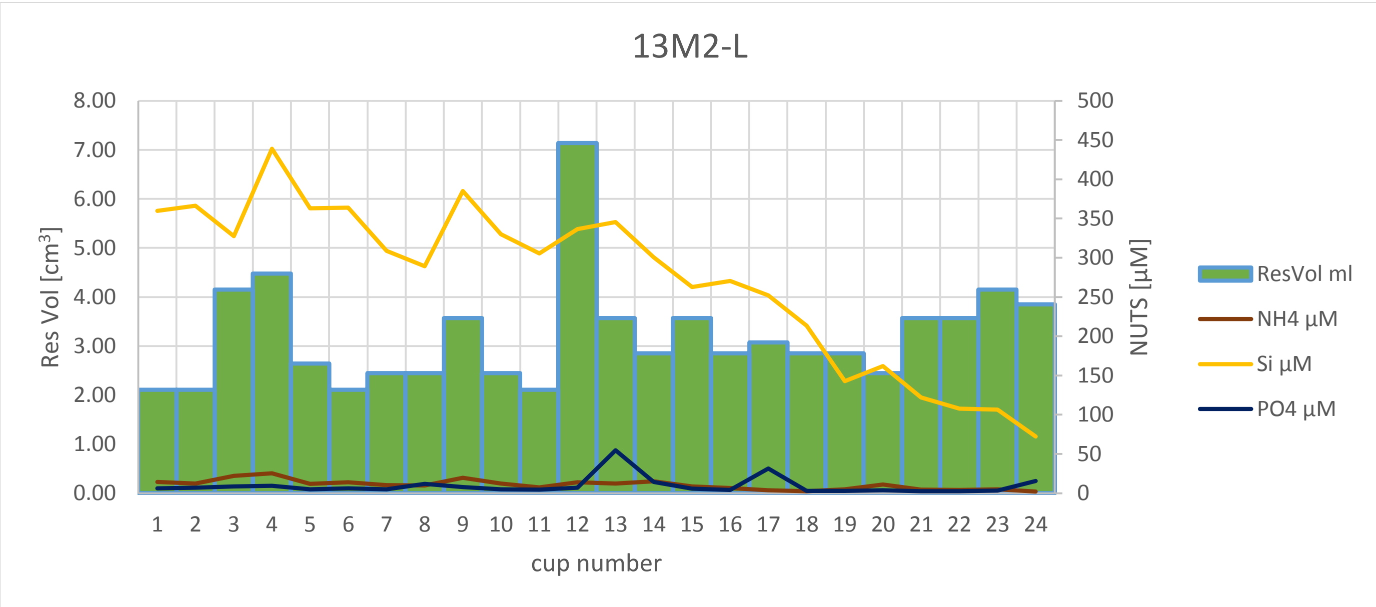


Fig. 5.7.4. 13M2 lower sediment trap estimated mass fluxes and nutrients

Mooring 13M3

During recovery of 13M3 the baffle of the upper trap (13M3-U) moved between the lower and upper cross wires and was badly damaged. Only four instead of at least six cross wires appeared to hold the baffle on top of the lower trap (13M3-L), which led to the complete loss of the baffle as it surfaced. More seriously, the titanium mooring bar inside the mooring pole of the upper trap was bent during the recovery of the mooring, and had partly torn across the uppermost part of the pole. While the lower trap had functioned flawlessly, the motor in the upper trap had not, thus yielding no samples at all. Values for pH in the lower trap ranged between 7.9 and 8.3 although the residue volumes were significantly higher than in the lower trap at nearby station 13M2. The nutrient analyses (Fig. 5.7.5) show similar values compared to the lower sediment trap of 13M2.

The damage to the titanium bar of the upper trap appeared unrepairable, and the redeployment of the mooring happened with only one sediment trap at 1200 meters depth below the ocean surface. The trap solutions of the upper trap (HgCl2 and Borax with seawater) were still untouched, and could therefore be redeployed directly.

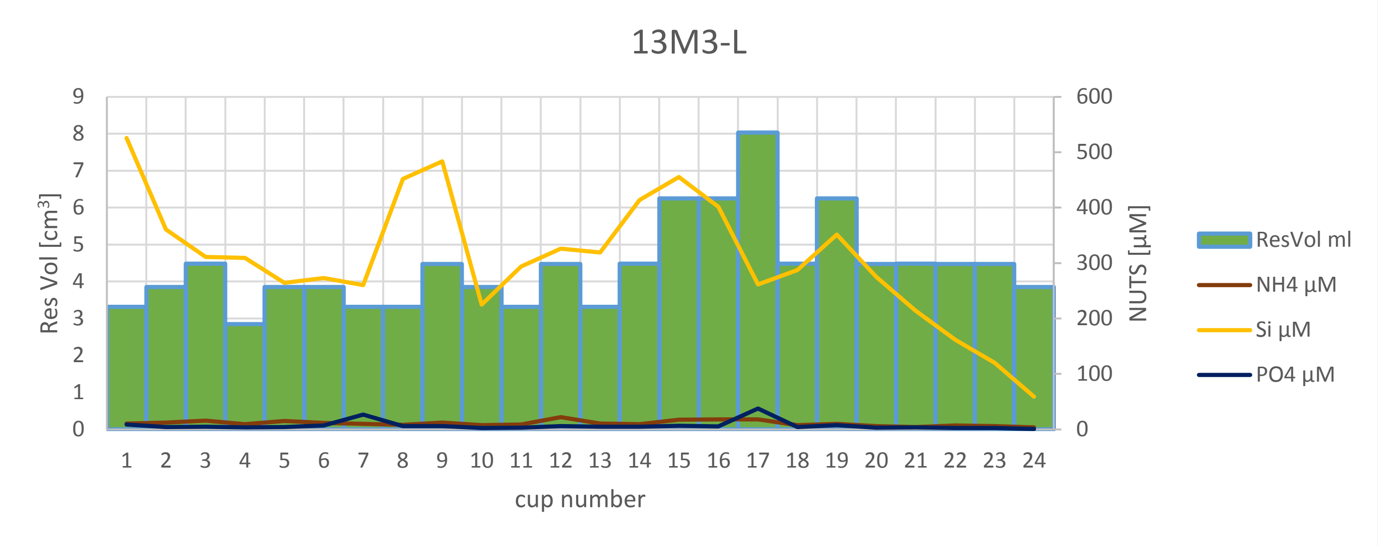


Fig. 5.7.5. 13M3 lower sediment trap estimated mass flux and nutrients

13M4

Both traps and the mounted instruments of mooring 13M4 were successfully recovered and both traps worked well. The pH values ranged from 7.0 (13M4-U14) to 8.3 (13M4-U18) in the upper trap and from 7.6 (13M4-L12) to 8.2 (13M4-L16) in the lower trap. As mentioned above, both sediment traps had peak fluxes in the same bottles (i.e. 12 and 24). Since both traps are synchronised, this was an indication for two single events and not just an artefact in one trap. In general the nutrient analyses show low values for the upper and lower trap (Fig. 5.7.6 & Fig. 5.7.7) with some exceptions for ammonium, which exceeds 1.8 mM in the upper trap (cup 12) and also shows elevated values in cup 12 & 24 in the lower trap.

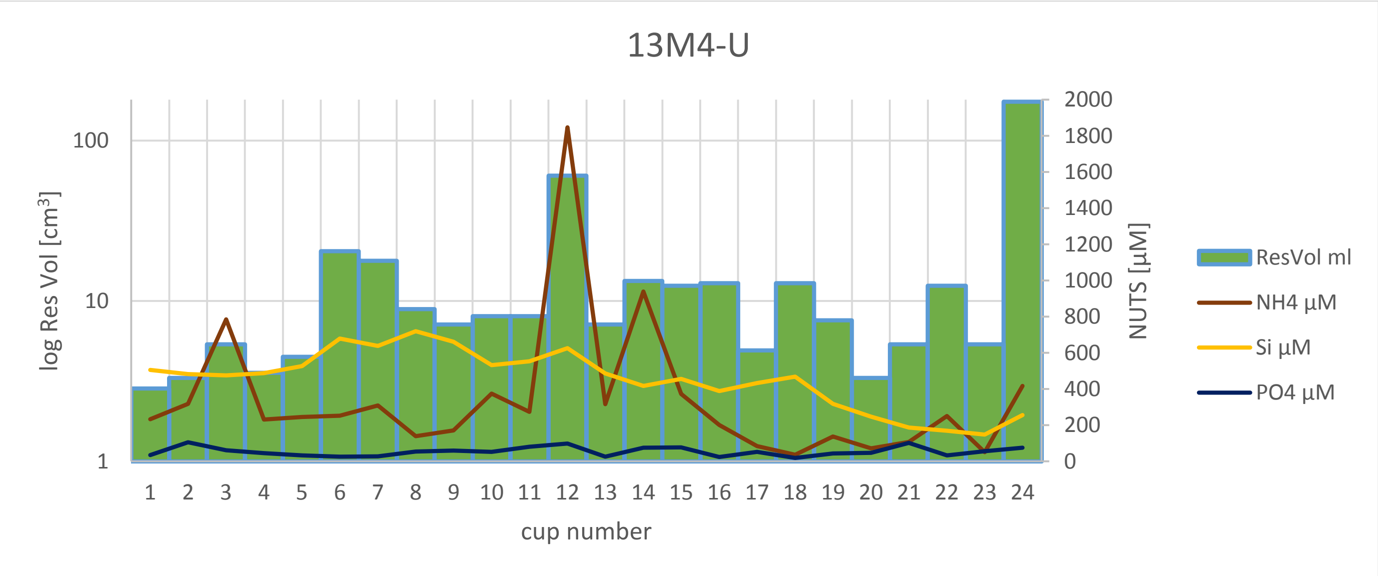


Fig. 1.7.6. 13M4 upper sediment trap estimated mass fluxes and nutrients

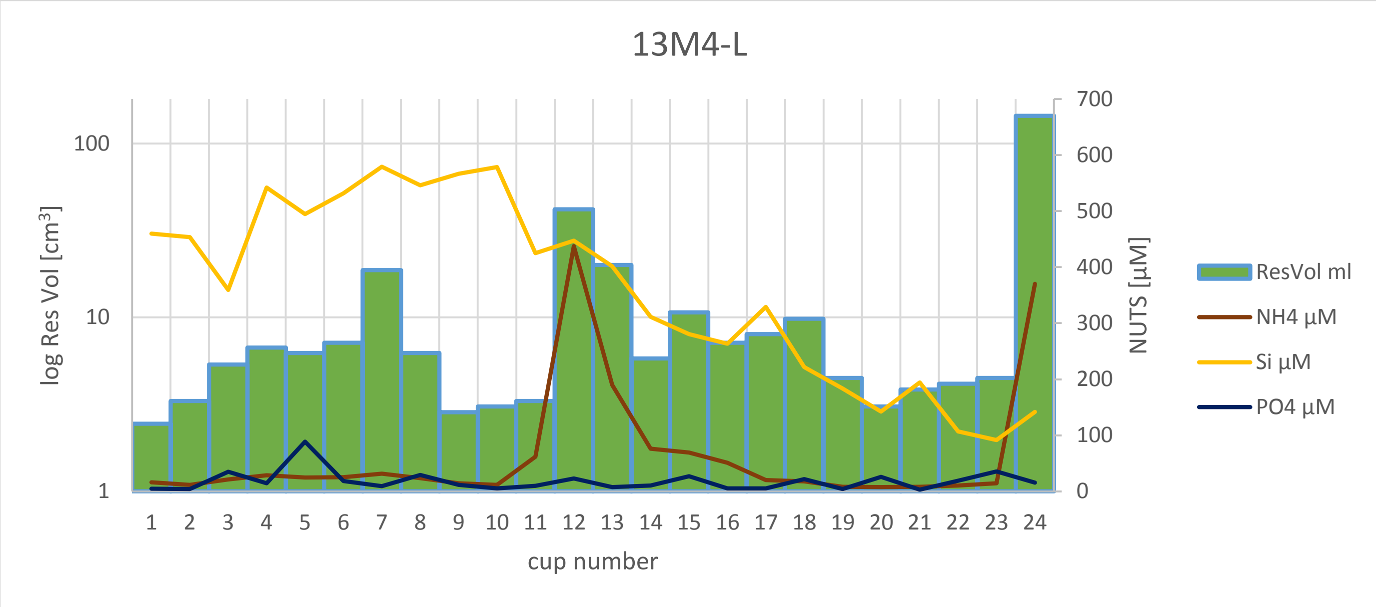


Fig. 5.7.7. 13M4 lower sediment trap estimated mass fluxes and nutrients

The redeployment of the mooring M4 was done with all the planned instruments but just with one releaser because the other one did not work properly anymore.

13M5

During recovery of mooring M5 the upper sediment trap got lost. The lower sediment trap could be recovered in good shape after dredging. The pH vales vary between 7.5 (13M5-L11) and 8.4 (13M5-L21 & 22). As in the other lower sediment traps, the nutrient analyses show low vales (Fig. 5.7.8). A peak flux was measured in cup 11.

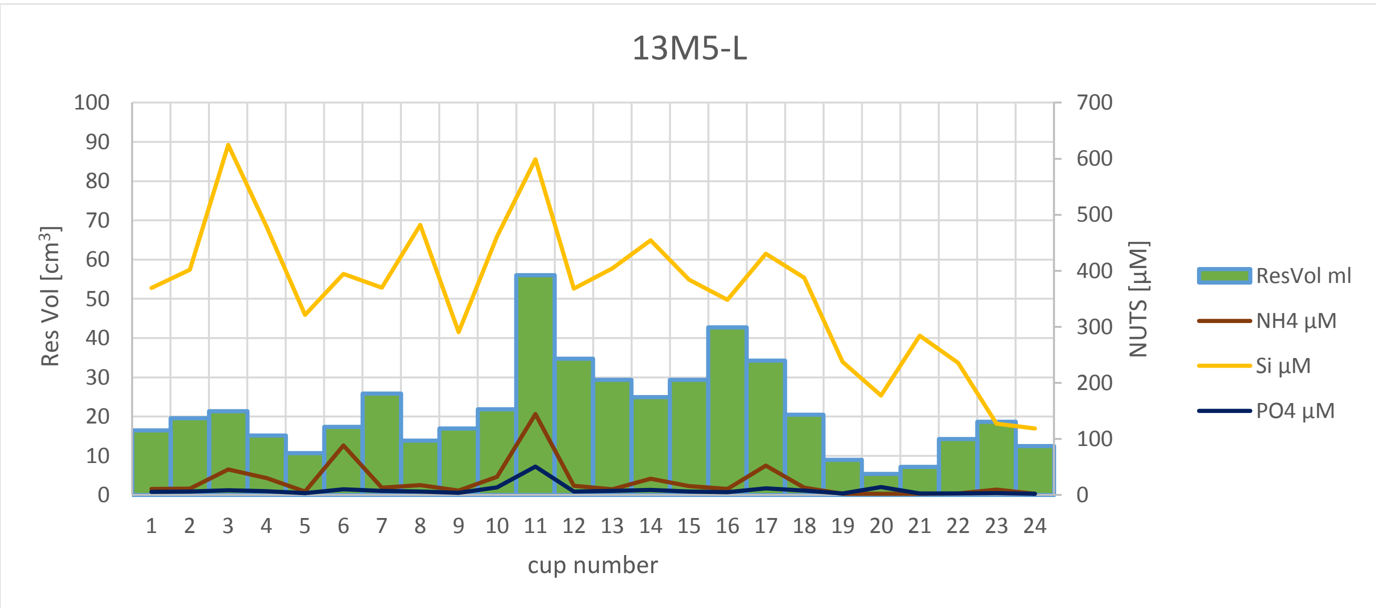


Fig. 5.2.8 13M5 lower sediment trap estimated mass fluxes and nutrients

Table 5.7.3. Sampling scheme of moorings M1-M5. Deployed October 2012 during Traffic I, M89, recovered November 2013 by RV Pelagia, Traffic II, 64PE378

Position	Start date UTC	Sample label
1	19-10-12 12:00	13-Mx-U/L1
2	4-11-12 12:00	13-Mx-U/L2
3	20-11-12 12:00	13-Mx-U/L3
4	6-12-12 12:00	13-Mx-U/L4
5	22-12-12 12:00	13-Mx-U/L5
6	7-01-13 12:00	13-Mx-U/L6
7	23-01-13 12:00	13-Mx-U/L7
8	8-02-13 12:00	13-Mx-U/L8
9	24-02-13 12:00	13-Mx-U/L9
10	12-03-13 12:00	13-Mx-U/L10
11	28-03-13 12:00	13-Mx-U/L11
12	13-04-13 12:00	13-Mx-U/L12
13	29-04-13 12:00	13-Mx-U/L13
14	15-05-13 12:00	13-Mx-U/L14
15	31-05-13 12:00	13-Mx-U/L15
16	16-06-13 12:00	13-Mx-U/L16
17	2-07-13 12:00	13-Mx-U/L17
18	18-07-13 12:00	13-Mx-U/L18
19	3-08-13 12:00	13-Mx-U/L19
20	19-08-13 12:00	13-Mx-U/L20
21	4-09-13 12:00	13-Mx-U/L21
22	20-09-13 12:00	13-Mx-U/L22
23	6-10-13 12:00	13-Mx-U/L23
24	22-10-13 12:00	13-Mx-U/L24

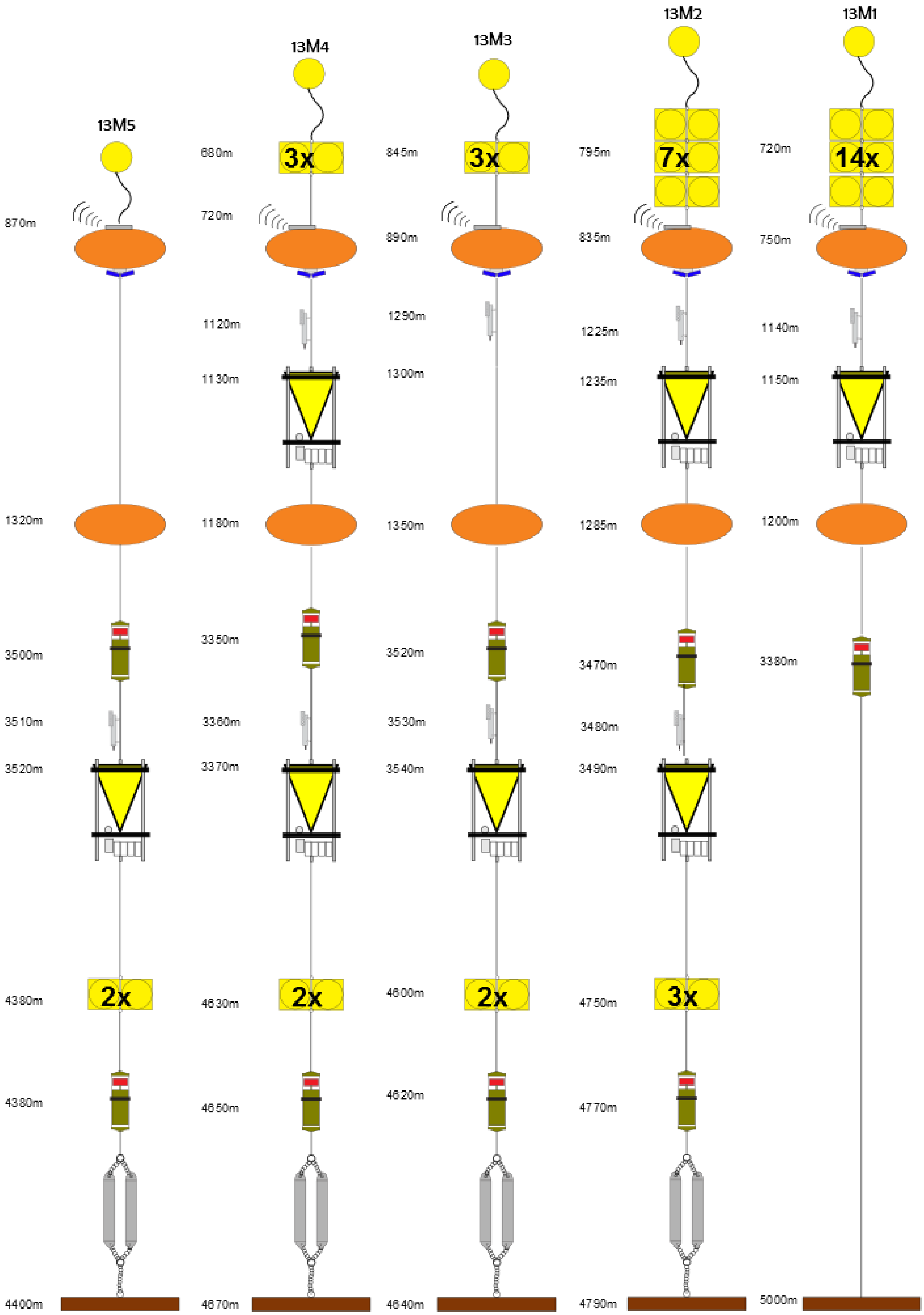


Figure 5.7.9. The five sediment-trap moorings recovered during 64PE378, that actually contain samples.

5.8 *Nutrient analyses* *Jan van Ooijen*

Summary

During this cruise about 300 samples were analysed for Phosphate, Silicate, and Ammonium content. 120 CTD samples were analysed immediately after the cruise for Nitrate and Nitrite. The samples were measured on a Seal-Analytical QuAAtro Autoanalyzer connected to an auto-sampler. The different nutrients were determined colorimetrical as described by Grashof (1983).

Methods

Samples were taken from a CTD rosette sampler and from several sediment traps. The sediment trap samples were poisoned with mercury chloride.

All CTD-samples were taken in a polypropylene bottle. The samples were sub-sampled in a 5 ml polyethylene vial. These vials were filtered through a 0.2µm acrodisc and stored dark at 4 °C. All CTD-samples were analysed within 18 hours on a QuAAtro auto-analyser. As a light source the QuAAtro uses a LED instead of a lamp to avoid the noise effect of the movements of the ship on the light source and therefore on the baseline.

Standards were prepared fresh every day by diluting the stock solutions of the different nutrients in nutrient depleted surface ocean water. This water is also used as baseline water. Each run of the system had a correlation coefficient for 11 calibrant points of at least 0.9999. The samples were measured from the lowest to the highest concentration in order to keep the carry over effects as small as possible.

In every run a mixed nutrient standard containing phosphate, silicate and nitrate in a constant and well known concentration was measured as a triplicate. Also a reference standard was measured as a triplicate in all runs to check the concentration of the mixed nutrient standard. This reference standard (Lot BT) made by Kanso in Japan, was ready to use and contained a known concentration of phosphate, silicate, nitrate and nitrite.

Analytical Methods

The colorimetric methods used are as follows:

- Ortho-Phosphate (PO_4) reacts with ammonium molybdate at pH 1.0, and potassium antimonyltartrate is used as a catalyst. The yellow phosphate-molybdenum complex is reduced by ascorbic acid and forms a blue reduced molybdophosphate-complex which is measured at 880nm (Murphy & Riley, 1962).
- Ammonium (NH_4) reacts with phenol and sodiumhypochlorite at pH 10.5 to form an indo-phenolblue complex. Citrate is used as a buffer and complexant for calcium and magnesium at this pH. The blue color is measured at 630nm. Koroleff, 1969 and optimized by W. Helder and R. de Vries, 1979.
- Silicate (Si) reacts with ammonium molybdate to a yellow complex and after reduction with ascorbic acid, the obtained blue silica-molybdenum complex is measured at 820nm. Oxalic acid is added to prevent formation of the blue phosphate-molybdenum (Strickland & Parsons, 1968).

Table 8.8.1. Statistics of the analysis of cruise 64PE378

Standard deviation of the 3rd calibrant in the same run (N=12)	Standard deviation of mixed nutrient standard between runs (N=32)	Detection limit
PO_4 0.004µM	PO_4 0.006µM	PO_4 0.005µM
Si 0.040µM	Si 0.051µM	Si 0.007µM
NH_4 0.010µM	NH_4 0.049µM	NH_4 0.010µM

5.9 *Mooring deployments* *Jan-Berend Stuut*

The original experiment setup with an instrument pool of ten traps distributed over five moorings along a transatlantic transect at 12°N could not be maintained due to the loss of several pieces of equipment and the shortness of time related to the experienced damage. In fact, only five traps were re-deployed (see Figure 5.9.1).

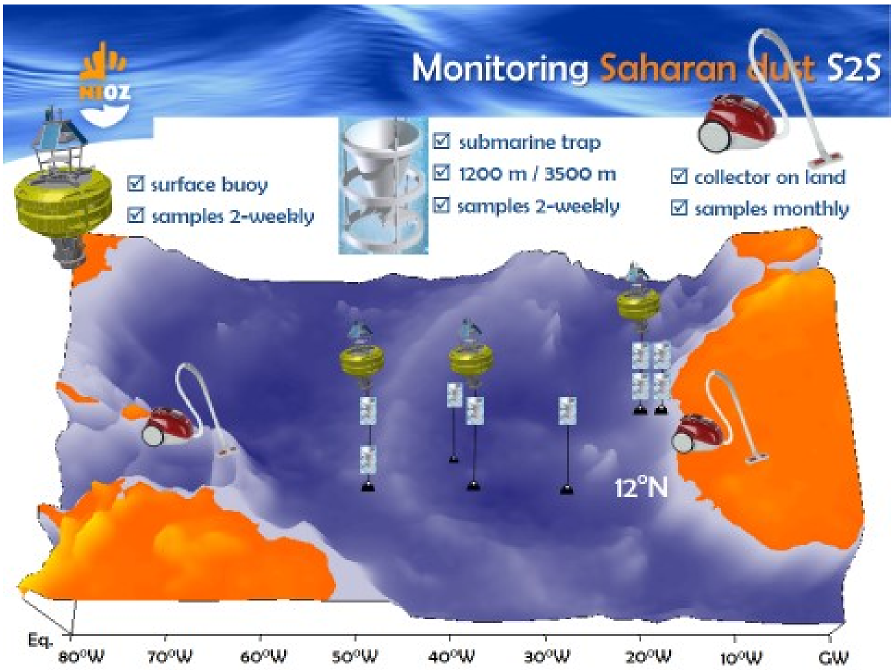


Figure 5.9.1: Layout of the transatlantic array of moored instruments for the sampling year 2013-2014. See Annex I for a detailed sketch of each mooring.

Although the amount of moored sediment traps was decreased by 50% relative to the sampling year 2012-2013, the transatlantic transect was extended with three moored dust-collecting buoys (see paragraph 5.10) as well as a dust collector that was installed on the island of St Eustatius (see paragraph 5.11.2).

The positions of the four sediment-trap moorings are presented in Table 5.9.1.

Table 5.9.1. Positions of the moored sediment traps deployed during cruise 64PE378

Station	Lat (° ' "N)	Lon (° ' "W)	Water depth (m)	Traps
14M1	11°59'47.778"	23°0'30.366"	5000	1200
14M2	13°48'41.400"	37°49'27.960"	4729	1200
14M3	12°23'45.049"	38°37'39.731"	4680	1200
14M4	12°3'46.386"	49°11'28.417"	4974	1200 3500

Keeping in mind that the recovery cruise is planned in October 2014 with RV Pelagia sailing from West to East, the sediment traps were pre-programmed in order to maximize the temporal resolution and minimize the amount of gaps in the sampling scheme, also with regard to the 2013 deployment from East to West. The sampling interval of each of the traps and buoys are presented in Annex.

Sample cups were filled with seawater collected at the deployment depth of each trap, in which a biocide (9.375 g of $HgCl_2$; end-concentration 1.29 g L^{-1}) and a pH-buffer (9.375 g of $Na_2B_4O_7 \cdot 10H_2O$; end concentration 1.29 g L^{-1}) were dissolved, supplemented by milliQ-water (500 mL on 6.75 L of seawater) to a density slightly in excess of the ambient seawater. A blank sample was taken for later comparison with the actual collecting cups to determine in-situ chemical decomposition fluxes.

Generally, due to numerous cases of bad luck, the moorings had to be adapted. Due to time constraints and material damage, no mooring was re-deployed at station M5. Also, it was decided not to re-deploy the deep current meters near the sea floor. At stations M1, M2, and M3, also the deep current meters at the depth of the deep traps (3500m) were omitted at re-deployment.
At recovery of mooring 13M1 at station M1, the titanium bar had broken. For this reason, only the shallow trap was re-deployed, and using a cable from the new supplier (Roodenberg). At station M2, this cable turned out to be unreliable; the sockets broke at deployment of 14M2. For this reason, it is to be feared that mooring 14M1 at station M1 will break during recovery.
In comparison to the original mooring 13M1, mooring 14M1 does not have any instruments below the lower smartie at 1250m.

It was decided that at the following stations, the old cables should be re-used. This has consequences for the recovery of those moorings as there is a risk of material damage and therefore weaknesses in the cables.

At station M2 the cable that was used to deploy the mooring in 2012 was re-used because the new cable broke during re-deployment of mooring 14M2, because of which the lower trap was lost. Therefore, also mooring 14M2 consists of solely the trap at 1200m, and has no instruments below the lower smartie at 1250m.

At station M3, during recovery of mooring 13M3, it turned out that the titanium bar inside the lower sediment trap was damaged. For this reason, it could not be re-deployed. Also mooring 14M3, at station M3 consists of solely the trap at 1200m, and has no instruments below the lower smartie at 1250m.

At station M4, for the first time we could re-deploy a full sediment-trap mooring, including the deep trap and deep current meters at 3336 and 4612m water depth, respectively. However, during recovery of mooring 13M4, one of the releasers turned out to have a malfunction. For this reason, mooring 14M4 had to be re-deployed with only one releaser.

At station M5, after losing the upper trap, the recovery of mooring 13M5 including dredging took so much time that we were forced to sail on to St Maarten, without having a chance to re-deploy mooring 14M5. For this reason, sadly, no mooring was deployed at station M5 at all.

In general, apart from material damage, the deployments of all moorings went really smooth thanks to the excellent collaboration between the ship's crew and technicians.

Figure 5.9.2: Deployments are generally concluded with a big splash!

Table 5.9.2. Moorings M1-M4. Deployed in November - December 2013 during Traffic II, 64PE378, to be recovered in October 2014 by RV Pelagia, Traffic III, 64PE395, sailing from West to East.

Sample	Start (12.^{00} UTC)	Sample	Start (12.^{00} UTC)	Sample	Start (12.^{00} UTC)	Sample	Start (12.^{00} UTC)
14-M1-U1	23-11-13	14-M2-U1	1-12-13	14-M3-U1	1-12-13	14-M4-U/L1	9-12-13
14-M1-U2	1-12-13	14-M2-U2	9-12-13	14-M3-U2	9-12-13	14-M4-U/L2	17-12-13
14-M1-U3	9-12-13	14-M2-U3	17-12-13	14-M3-U3	17-12-13	14-M4-U/L3	25-12-13
14-M1-U4	17-12-13	14-M2-U4	25-12-13	14-M3-U4	25-12-13	14-M4-U/L4	2-01-14
14-M1-U5	25-12-13	14-M2-U5	10-01-14	14-M3-U5	10-01-14	14-M4-U/L5	10-01-14
14-M1-U6	10-01-14	14-M2-U6	26-01-14	14-M3-U6	26-01-14	14-M4-U/L6	26-01-14
14-M1-U7	26-01-14	14-M2-U7	11-02-14	14-M3-U7	11-02-14	14-M4-U/L7	11-02-14
14-M1-U8	11-02-14	14-M2-U8	27-02-14	14-M3-U8	27-02-14	14-M4-U/L8	27-02-14
14-M1-U9	27-02-14	14-M2-U9	15-03-14	14-M3-U9	15-03-14	14-M4-U/L9	15-03-14
14-M1-U10	15-03-14	14-M2-U10	31-03-14	14-M3-U10	31-03-14	14-M4-U/L10	31-03-14
14-M1-U11	31-03-14	14-M2-U11	16-04-14	14-M3-U11	16-04-14	14-M4-U/L11	16-04-14
14-M1-U12	16-04-14	14-M2-U12	2-05-14	14-M3-U12	2-05-14	14-M4-U/L12	2-05-14
14-M1-U13	2-05-14	14-M2-U13	18-05-14	14-M3-U13	18-05-14	14-M4-U/L13	18-05-14
14-M1-U14	18-05-14	14-M2-U14	3-06-14	14-M3-U14	3-06-14	14-M4-U/L14	3-06-14
14-M1-U15	3-06-14	14-M2-U15	19-06-14	14-M3-U15	19-06-14	14-M4-U/L15	19-06-14
14-M1-U16	19-06-14	14-M2-U16	5-07-14	14-M3-U16	5-07-14	14-M4-U/L16	5-07-14
14-M1-U17	5-07-14	14-M2-U17	21-07-14	14-M3-U17	21-07-14	14-M4-U/L17	21-07-14
14-M1-U18	21-07-14	14-M2-U18	6-08-14	14-M3-U18	6-08-14	14-M4-U/L18	6-08-14
14-M1-U19	6-08-14	14-M2-U19	22-08-14	14-M3-U19	22-08-14	14-M4-U/L19	22-08-14
14-M1-U20	22-08-14	14-M2-U20	7-09-14	14-M3-U20	7-09-14	14-M4-U/L20	7-09-14
14-M1-U21	7-09-14	14-M2-U21	23-09-14	14-M3-U21	15-09-14	14-M4-U/L21	15-09-14
14-M1-U22	23-09-14	14-M2-U22	1-10-14	14-M3-U22	23-09-14	14-M4-U/L22	23-09-14
14-M1-U23	9-10-14	14-M2-U23	9-10-14	14-M3-U23	1-10-14	14-M4-U/L23	1-10-14
14-M1-U24	17-10-14	14-M2-U24	17-10-14	14-M3-U24	9-10-14	14-M4-U/L24	9-10-14

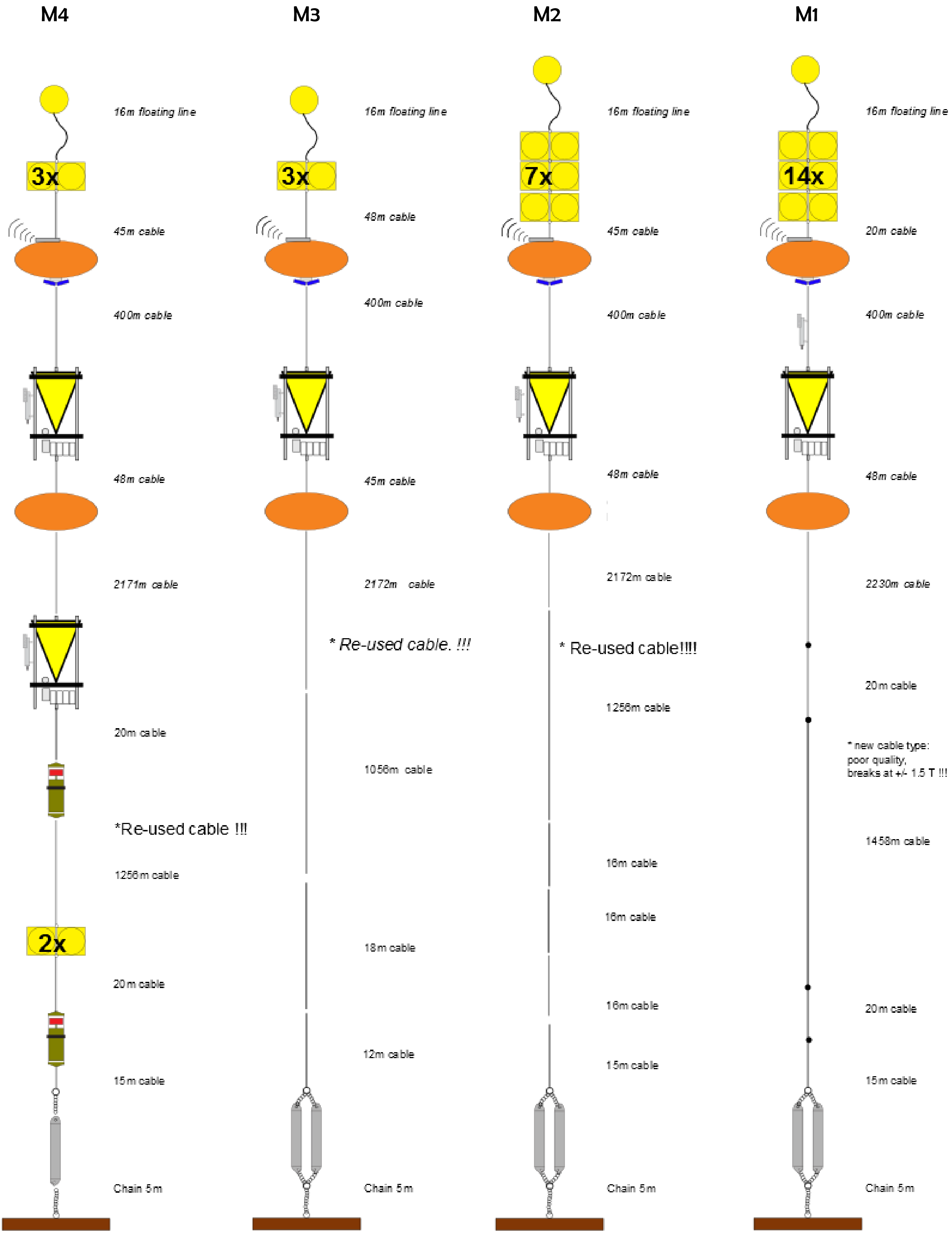


Figure 5.9.2: Sketches of the four sediment-trap moorings deployed during 64PE378

5.10 *Buoy deployments* *Jan-Berend Stuut*

A new addition to the trans-Atlantic transect of dust-collecting instruments consists of three dust-collecting buoys that collect dust autonomously by sucking air through a filter. The new buoys were designed, constructed, and developed at NIOZ. Their principle is much like a submarine sediment trap in that they consist of a carrousel with 24 filters. The filters rotate one-by-one in front of a chimney through which air is pumped daily at a prescribed interval. At 10.00 AM UTC, the daily routine starts; before the air pump starts sucking air through the filters, a meteorological station determines the weather and sea state. If there is rain (>0.2mm/min) or too strong wind (>20m/s), the air inlet does not open. During a period of eight hours, the weather is monitored and when conditions are favourable for at least one hour within those eight hours, the sampling scheme is initiated after all. For two hours, air is sucked through the filter. If during those two hours the weather changes to unfavourable conditions, the schedule is aborted automatically. The filters are exchanged in sync with the submarine sediment traps, see table 10.1.

Table 10.1: Key data of the buoys deployed during PE378

Station	Device	Lat (° ' "N)	Lon (° ' "W)	Start date	Sampling Interval
13CB	Buoy: Carmen	21°15'49.440"	20°55'18.480"	19 Nov 2013	19-20 days
13M3	Buoy: Michèlle	12°19'29.760"	38°44'36.180"	1 Dec 2013	16 days
13M4	Buoy: Laura	11°57'41.339"	49°4'7.144"	9 Dec 2013	16 days

Twice daily, the buoys report the meteorological conditions (wind speed, wind direction, temperature, humidity) as well as the buoy's conditions (battery status, position, pitch, roll, heading, filter nr, amount of air filtered) through eMail. The contact is bi-directional; the measuring parameters can be altered remotely. This is especially important for buoy Carmen, which collects dust off Cape Blanc, in sync with submarine sediment traps that are serviced by the MARUM-Bremen group. Usually, this group services their traps in late winter – early spring. As their sampling scheme also depends on available shiptime, it is sometimes adapted.

Deployment of the buoys was always carried out, just like the other moorings, "top down". The first piece of equipment to touch the water surface is always a smartie, which acts as a dummy buoy. The last piece of the mooring is always the anchor. After the weight is deployed, the dummy buoy is dragged under water due to the speed of the anchor's sinking. A parachute prevents the anchor weight from sinking too fast but still the dummy buoy is dragged under water. At some point, when the anchor weight is standing on the seafloor, the mooring erects itself and at this point the top smartie can be exchanged with the real buoy.

Figure 5.10.1: Photos of the buoys "in action". Left; at the start of deployment of buoy Michelle, the deck is still full with chains, lines, and various pieces of equipment. Right; buoy Laura just after deployment.

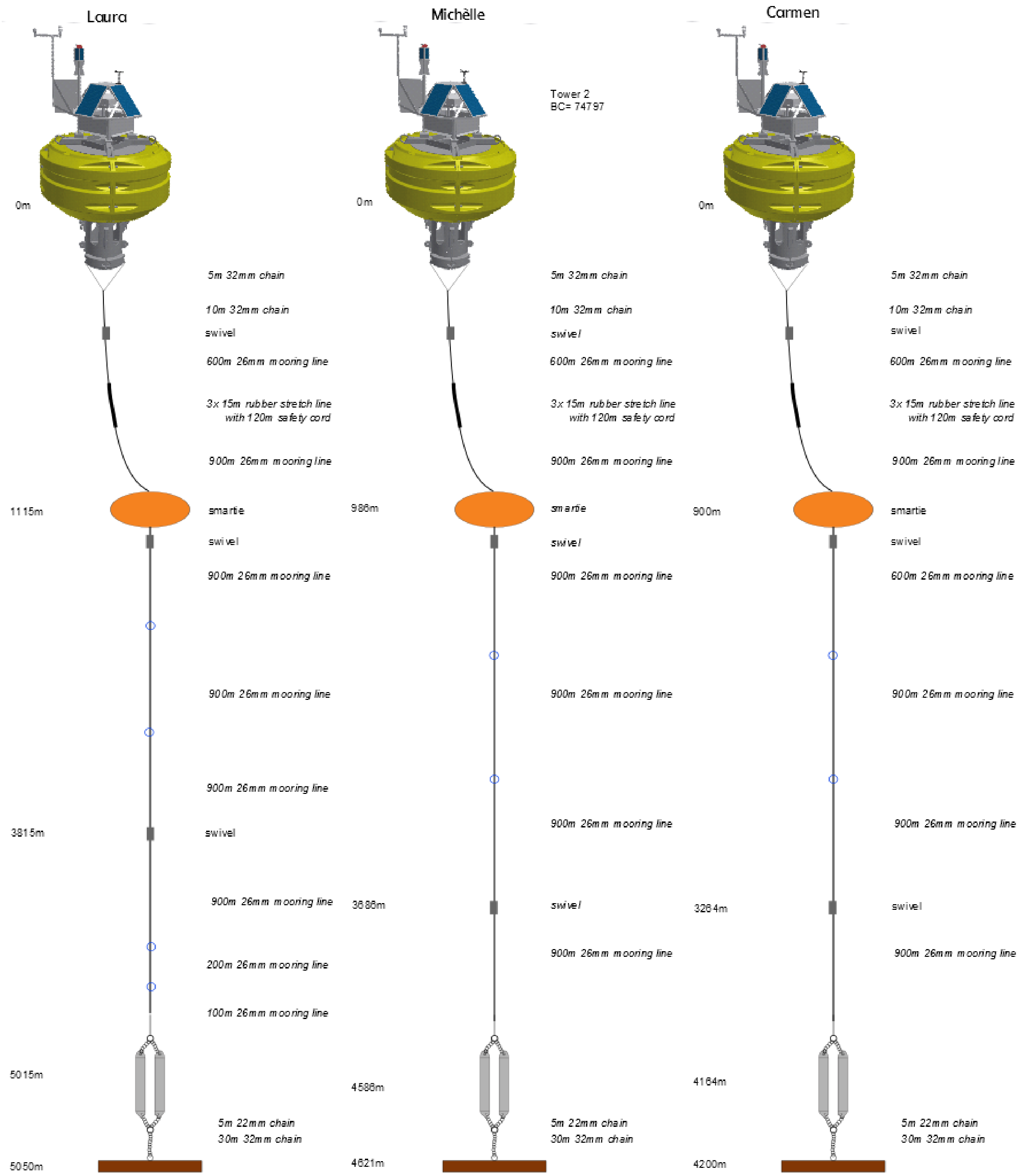


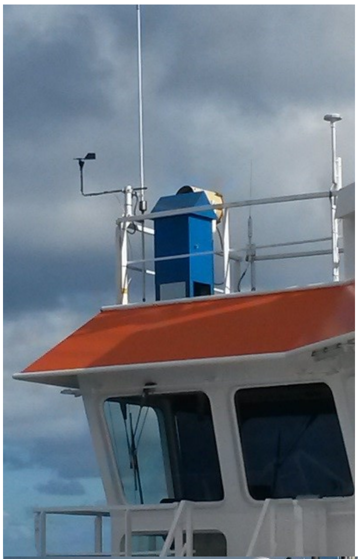
Figure 5.10.2: Sketches of the three dust-collecting buoys deployed during 64PE378

5.11 *Mineral-dust sampling*

5.11.1 *On-board dust sampling*

Chris Munday

Studying mineral dust sampled with filters on board *RV Pelagia* allows gathering important information with respect to the modern composition of mineral dust as well as its origin, transport and depositional mechanisms. Understanding modern mineral dust composition, mobilization and involvement in feedback mechanisms is not only required in order to provide data for climate models but also to aid interpreting dust deposits in marine palaeo-environmental sediment core records with respect to past climate reconstructions. Microbiological analysis also allows investigation into the bacterial community composition of the transported dust and scan for any species of human or agricultural interest.



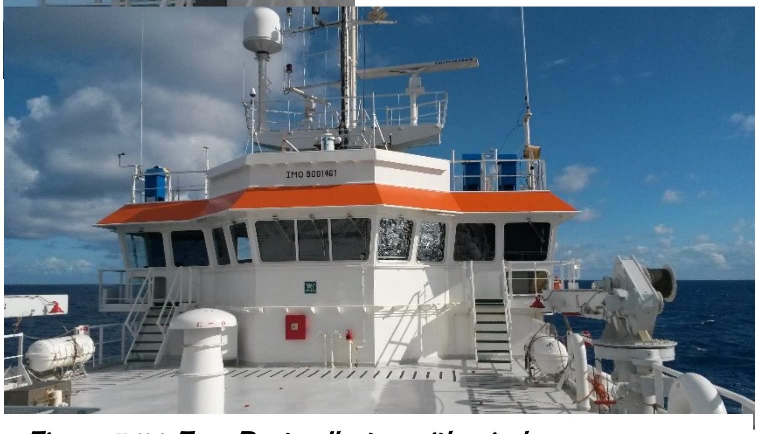


Figure 5.11.1: Top: Dust collector with wind vane.
Bottom: Location of the dust collectors above the bridge

Aerosol sampling was performed with 3 Hi-volume Anderson dust collectors mounted above the bridge of the ship. Each collector contains a motor which sucks air through an air filter mounted on top, underneath a rain cover.
The collectors are connected to a wind vane which is programmed to have the units switch on when wind is coming from a predetermined arc in front of the ship, and off at other times. This is to prevent contamination from the ship's chimney. Originally, the 'on' range was approximately 45° to each side of 0° (straight ahead). After observation of the prevailing wind, it was decided that the arc could be widened, to approximately 70° to port and 100° to starboard to allow collection of aerosols for a longer time. The arc was narrower on the port side, as that is the same side of the ship as the chimney, and therefore was more likely to contaminate the samples should the wind be any more perpendicular to the ship.
A logger on board each collector monitors the volume of air collected, and increases the suction when the filter gets loaded with material to maintain a constant air flow.
Each of the dust collectors contained a filter made from a different material; Glass Fibre (GF/F), Cellulose Acetate (CA) and Polycarbonate (PC), allowing for multiple analyses. The glass fibre filter were pre-combusted at NIOZ and stored in pre-combusted aluminium foil, and will be used to analyse lipid content of the aerosols. The polycarbonate filter will be ashed for analysis of grain size, as well as leaching experiments to determine mineral bio-availability. The cellulose acetate filter will be used to analyse bacterial and chemical composition. To enable bacterial analysis, immediately after the filter was removed from the sampling unit a disc of approximately 47mm diameter was cut from the CA filter using ethanol cleaned instruments and stored at -20°C. The GF/F filter was stored at -80°C.
Several samples were collected while the ship was stationary, as noted in the table below, while others were while the ship was in motion at all times. A total of 10 samples were collected, 2 of which spanned only station time (M2, M4).

During the first 7 days of the cruise, while travelling in a southerly direction, the wind was exclusively at our back, preventing use of the dust collectors, except for a brief time while at station CB, with the ship turned to the wind. In addition, power supply problems limited the sampling time, however this was solved shortly after departure from CB.

Despite the sampling arc being expanded, the wind continued to blow from behind the ship, limiting the sample volumes at times. Rain affected sampling during samples 6 and 9, resulting in the samplers being switched off overnight on both occasions.

The first few samples collected, while on the coastal leg of the voyage showed some grey/brown material on the filters. However, once the course of the voyage turned to the west, progressively less visible material was seen on the filters.

5.11.2 Dust collection on St Eustatius *Jan-Berend Stuut*

Another addition to the transatlantic collection of Saharan dust is a High-Volume dust collector that we installed on the east coast of the island St Eustatius. The dust collector was positioned on the roof of a shed near the slaughter house, which is situated at the north-eastern edge of the main village. This building is the sole building that is both relatively close (<1km) to the eastern cliff coast and has electrical power, see Figure 5.11.2.

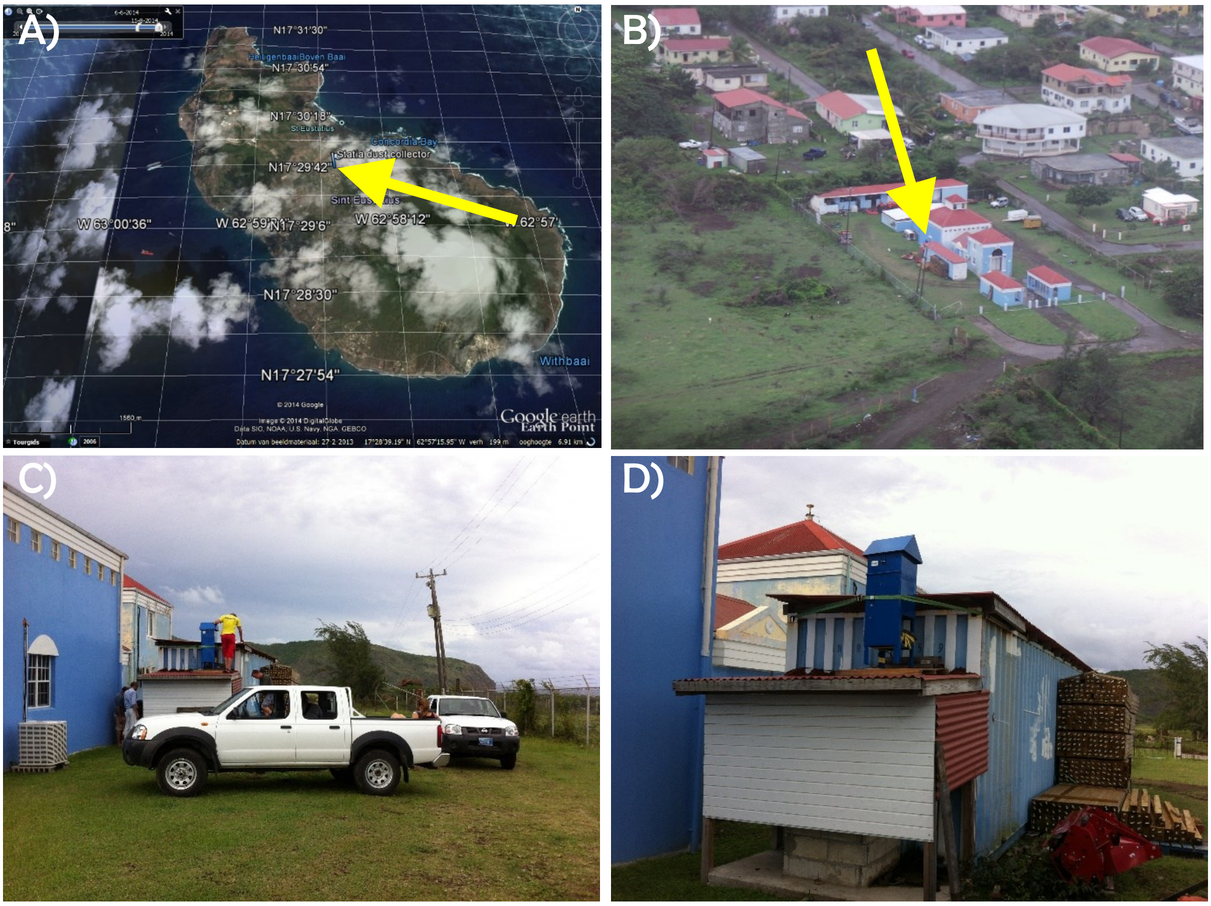


Figure 5.11.2: Dust collection on the island of Statia. A) & B) Flag and arrows indicate dust collector on the slaughter house's shed. C) & D) close up of the dust collector, Johan Stapel (in C) for scale.

Filters are exchanged every two weeks by Johan Stapel, who manages the Caribbean Netherlands Science Institute (CNSI) on the island. Meteorological data will be available from the nearby airport.

6 *Acknowledgements*

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Back home, many people were involved in the preparation of the cruise and of all the instruments. Our genuine thanks go to Edwin Keijzer and Roel Bakker (NIOZ-MTI) and Matthias Schrama (Schrama Metaaltechniek) for designing and constructing the dust-collecting masts. Furthermore, we thank Jack Schilling, Harry de Porto, Jan Blom, and Piet Grisnigt (NIOZ-MTM) for helping out with the preparation of the moorings, cables, and swivels and transport of them. Peter-Roy Alkema, Mildred Jourdan, Erica Koning, and Thomas de Greef are thanked for help with logistics and planning and Pieter Honkoop, Marcel van der Linden and Irene Wernand for administrative support.
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Participants of 64PE378
L2R, standing: Ronald, Michèlle, Roald, Jan, Carmen, Jan-Berend, Laura, Chris, Esmee, Sietske, Brett, Geert-Jan, Ger, Yvo, Michael, Leon, Alle, Bob.
L2R, sitting: Jose, Martin, Jan-Dirk, Alex, Iwan.
Not on picture: John, Joep, Jaap, Roel.

Station	Cast	Device	Date	Time (UTC)	Lat (N)	Lon (W)	Depth [m]	Comment
13CB	1	Multi Corer	11-nov-13	17:58	21°15' 59.27"	20°49' 8.666"	4198	10 tubes / average length: 30 cm
	2	Buoy	11-nov-13	12:54	21°15' 47.434"	20°55' 20.51"	4200	Deployment Carmen
	3	CTD	12-nov-13	18:54	21°16' 36.196"	20°55' 8.137"	4200	
	4	MultiNet	12-nov-13	21:58	21°17' 35.635"	20°53' 45.272"	0-800	Start heave / deep
	5	MultiNet	13-nov-13	1:20	21°20' 31.11"	20°48' 23.764"	0-150	Start heave / shallow
	6	Mooring	13-nov-13	11:02	21°16' 24.863"	21°0' 1.897"		Recovery old Buoy mooring
13M0	1	Multi Corer	16-nov-13	1:50	13°0' 31.835"	21°7' 48.158"	4700	11 tubes / average length: 36 cm
	2	Piston Core	16-nov-13	5:41	13°0' 31.95"	21°7' 48.112"	4700	Length: 9.30 m
13M1	1	MultiNet	16-nov-13	22:20	12°01' 22.92"	22°59' 23.94"	0-800	Start heave / deep
	2	CTD	17-nov-13	5:46	12°0' 55.02"	23°0' 51.3"	5040	
	3	Mooring	17-nov-13	7:00	11°59' 48.12"	22°59' 58.94"	5000	lost lower sediment trap (3500m)
	4	Piston Core	17-nov-13	13:08	11°59' 54"	23°0' 12"	5040	Length: 0.30 m
	5	Mooring	17-nov-13	19:45	11°59' 47.778"	23°0' 30.366"	5000	Deployment M1 upper sediment trap (1200m)
13M1-A	1	Multi Corer	20-nov-13	2:53	12°51' 57.654"	31°9' 27.994"	5871	2 tubes / average length: 4 cm
	2	Multi Corer	20-nov-13	6:41	12°51' 54.349"	31°9' 29.07"	5878	9 tubes / average length: 45 cm
	3	Piston Core	20-nov-13	10:38	12°51' 52.567"	31°9' 33.379"	5871	Length: 9.54 m
13M2	1	CTD	22-nov-13	5:40	13° 48' 41.494"	37° 49' 46.844"	4884	Water for sediment trap preparation M2 & M3
	2	Mooring	22-nov-13	8:00	13° 48' 36.526"	37° 49' 27.988"		Recovery M2
	3	MultiNet	22-nov-13	22:50	13° 49' 22.976"	37° 50' 2.09"	0-800	Start heave / deep
	4	MultiNet	23-nov-13	0:03	13° 50' 32.384"	37° 48' 20.124"	0-150	Start heave / shallow
	5	Mooring	23-nov-13	14:45	13° 48' 38.653"	37° 49' 13.321"	4729	Deployment M2 upper sediment trap (1200m)
	6	Piston Core	23-nov-13	19:01	13° 43' 17.706"	37° 51' 50.155"	4749	Length: 9.24 m
13M3	1	Mooring	24-nov-13	10:01	12° 23' 40.819"	38° 37' 41.668"		Recovery M3 (upper sediment trap bottles empty)
	2	Buoy	24-nov-13	22:28	12° 19' 33.031"	38° 44' 28.036"	4621	Deployment Michèlle
	3	Mooring	25-nov-13	22:22	12° 23' 45.049"	38° 37' 39.731"	4680	Deployment M3 upper sediment trap (1200m)
13M4	1	Buoy	28-nov-13	17:49	11° 57' 41.339"	49° 4' 7.144"	4960	Deployment Laura
	2	CTD	28-nov-13	23:06	11° 58' 56.125"	49° 5' 54.884"	5040	
	3	MultiNet	29-nov-13	2:14	12° 0' 0.709"	49° 5' 16.048"	0-800	Start heave
	4	MultiNet	29-nov-13	5:26	12° 3' 48.618"	49° 1' 49.296"	0-150	Start heave
	5	Mooring	29-nov-13	11:12	12° 3' 46.386"	49° 11' 28.417"		Recovery M4
	6	Piston Core	29-nov-13	16:05	12° 2' 18.316"	49° 9' 17.507"	5048	Length 7.21 m
	7	Mooring	29-nov-13	22:12	12° 2' 15.976"	49° 13' 11.701"	4974	Deployment M4
13M5	1	CTD	1-dec-13	20:56	11° 57' 12.715"	56° 54' 16.319"	4428	
	2	Mooring	2-dec-13	11:14	12° 1' 23.153"	57° 2' 53.686"		Recovery M5, lost both sediment traps
	3	Dredging	2-dec-13	14:58	12° 1' 8.742"	57° 3' 18.832"		failed
	4-HvH	Mooring	3-dec-13	10:57	11° 57' 6.667"	56° 56' 22.664"	4430	Recovery test mooring
	5	Piston Core	3-dec-13	13:08	11° 57' 27.918"	56° 56' 24.392"		Length 4.89 m
	6	Dredging	4-dec-13	2:33	11° 59' 57.214"	57° 7' 56.6"		caught lower sediment trap