Cruise Report
and preliminary results

DUST2021

Cruise No. 64PE482

12 January – 7 February 2021
Texel (The Netherlands) – Las Palmas de Gran Canaria (Spain)

Jan-Berend W. Stuut, Barry Boersen, Bob Koster, Jan-Dirk de Visser

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1. Summary

RV Pelagia cruise 64PE482 was dedicated to service dust-collecting buoys *Carmen* and *Laura* as well as high-resolution sediment-trap mooring M1. These instruments were originally deployed in November 2012 in the framework of a set of research projects focussing on Saharan dust:

1) TRAFFIC (NWO funded),
2) DUSTTRAFFIC (ERC funded),
3) Mineral aerosols in the Earth system (DFG funded)

After the termination of these projects in 2017, it was decided to continue the monitoring of Saharan-dust deposition in the eastern part of the north equatorial Atlantic Ocean through collaboration with German colleagues from MARUM, Bremen, who have been sampling Saharan dust deposition off Cape Blanc since 1988. Since 2013, dust-collecting buoy *Carmen* was added to this sediment-trap mooring, in order to compare Saharan dust that is being blown through the atmosphere with the dust that is deposited into the ocean. At station M1, south of the Cape Verde Islands, a similar set up of dust-collecting buoy *Laura* and a high-resolution sediment-trap mooring (three traps at about 1100m water depth, together sampling at 4-days' resolution) has been installed since 2016 during cruise JC134 onboard RRS *James Cook*.

The instruments were deployed for a bit less than one year and are to be serviced in the autumn of 2021 during a joint NIOZ-MARUM "SIPA" expedition onboard FS *Meteor.* Thanks to this relatively short period, the sampling resolution of two traps was set to 2 days. In July 2021 the buoys were foreseen to take part in the instrument calibration project ASKOS. To this end, the buoys would be sampling on a daily resolution. To accommodate this, the sampling resolution for the remaining months was set to 20 days. However, thanks to covid-19, ASKOS was postponed for another year and therefore, by the end of June, the sampling resolution was increased to 10 days.

In addition to servicing the dust-monitoring instruments, during cruise 64PE482 we also collected Saharan dust from the atmosphere with high-volume air samplers and from the water column with drifting traps.

Aim

Following the approach of combining dust-buoy data and samples and marine sediment-trap mooring samples, we aim to study the marine environmental impacts of Saharan-dust deposition.

Table 1.1: key data of dust-monitoring instruments, re-deployed during 64PE482

Instrument	Start date	Lat (° 'N)	Lon (° 'E)	End date	Nr cups	Interval
Buoy 21Carmen	3 Feb 2021	21°14.945'	21°3.140'	11 Dec 2021	24	20/10 days
Buoy 21Laura	28 Jan 2021	11°22.152'	22°58.390'	4 Dec 2021	24	20/10 days
Sed trap 21M1	30 Jan 2021	11°28.504'	22°42.486'	8 Dec 2021	117	2-4 days

2. Participants

Table 2.1: participants of cruise 64PE482

Name, title	Discipline	Affiliation
Barry Boersen	Marine Technology	NIOZ
Bob Koster	Marine Electronics	NIOZ
Jan-Berend W. Stuut, Dr	Marine Geology, chief scientist	NIOZ & VU
Jan-Dirk de Visser	Marine Technology	NIOZ

NIOZ – Royal Netherlands Institute for Sea Research, and Utrecht University, Texel, the Netherlands
VU – Vrije Universiteit Amsterdam, the Netherlands

3. Research program

The purpose of cruise 64PE482 was to recover and re-deploy dust-collecting buoys *Carmen* and *Laura*, as well as recover and re-deploy the high-resolution sediment-trap mooring M1, which is located at virtually the same position as buoy *Laura* (figure 3.1). At sea, dust was also collected *en route* from the ship's top deck, where two Anderson-type high-volume dust collectors were mounted. In addition, an *OMNI* 3000 aerosol sampler was used to collect dust in sterile water in the southern part of the study area. Finally, dust was also collected in rain through prototype wet-dust collectors, which were mounted on both buoys before they were re-deployed. Thanks to covid-19 related issues we had to pick up participants of the next expedition, but this was cancelled again during the cruise. In the end, this was very fortunate since the sea state at buoy Carmen was very unfavourable. Thanks to the new flexibility in the program, we could re-schedule and service buoy Carmen at the end of the expedition.

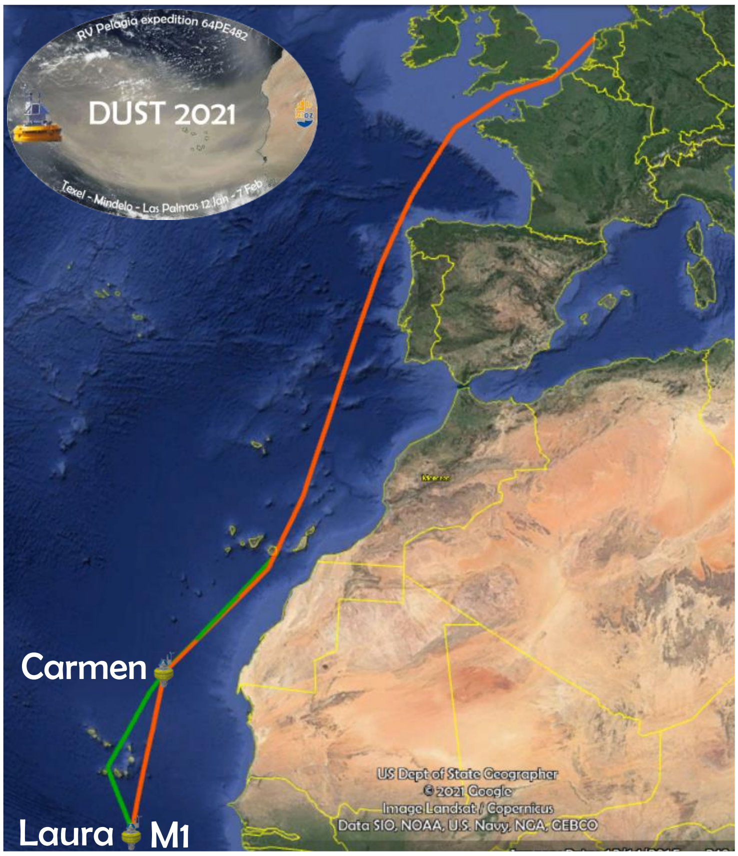


Figure 3.1: Cruise track (orange line for southbound, green for northbound) of cruise 64PE482; a total stretch of 4,150nm (~7,500km). The two monitoring stations Carmen *and* Laura/M1 *as well as the 200-miles' zones (EEZ) of the individual states are shown.*

4. Narrative of the cruise

Just after lunch on Tuesday 12 January 2021 at T_{air}=5.5°C and T_{water}=4.6°C, accompanied by a watery sun that creates a rainbow with the next rain shower, we leave the NIOZ harbour on Texel heading south for a twelve-day transit through the North Sea, the English Channel, the Bay of Biscaye, across the Madeira Abyssal Plain and past the Canary Islands.

Figure 4.1: leaving the NIOZ port on Texel, the Netherlands.

The first afternoon and night we make good progress and already by early next morning we see the white cliffs of Dover on starboard side. In the British Channel we struggle against waves, wind and tides but once we make it into the Bay of Biscay on Friday, we catch up speed again to about 9.5 knots. It turns out that we are lucky and sailing just in front of a large depression over the central North Atlantic, which causes rough seas just behind us.

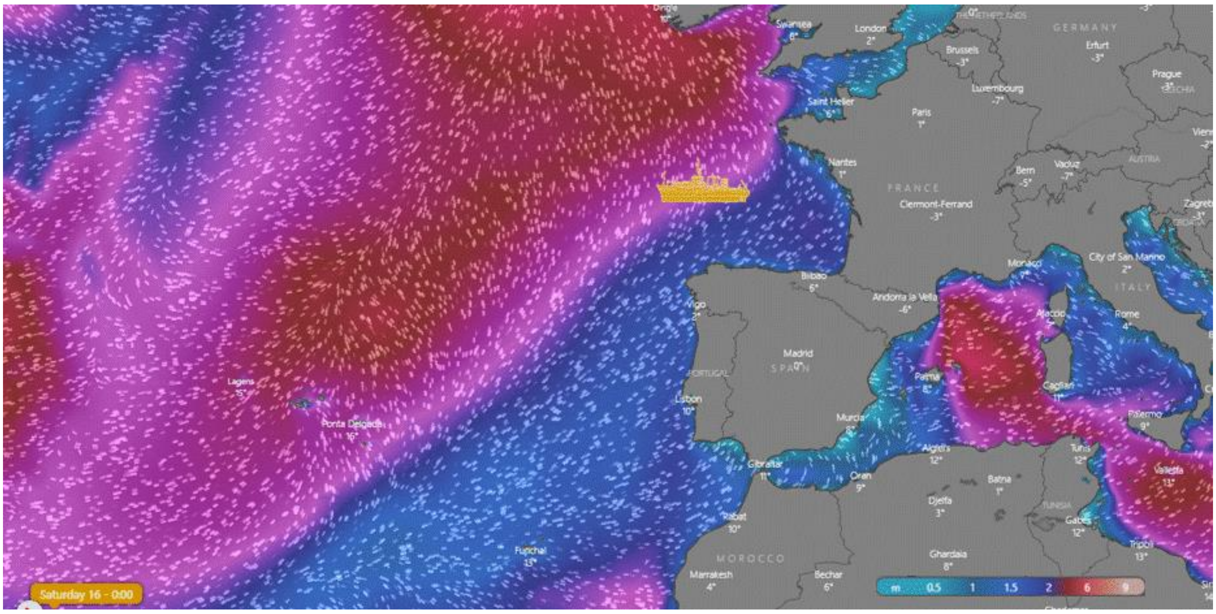


Figure 4.2: Windy® animation (see blog) of wave heights with position of RV Pelagia on 16 February.

On Thursday 21 January we pass the Canary Islands and just south of the island of Gran Canaria we do a test dip with the CTD in order to get good T and S data for the sound profile of the multibeam. Also, while lying still, we make a first test flight with the drone. This results in some nice footage of the ship.

Figure 4.3: View from a drone on RV Pelagia *in the middle of the ocean.*

On Friday 22 January at T_{air}=19.3°C and T_{water}=20.1°C we install and start the two high-volume dust collectors on the top deck of the ship. As we are practically sailing downwind, the collectors do not sample to prevent contamination of particles from the ship's chimney.

On Saturday 23 January just after noon we reach the site of buoy *Carmen*. However, with a wind speed of 11m/s and the aftermath of a storm still kicking up waves, we decide that the sea is too rough to safely recover the buoy. There is a small window of flexibility in the program as the three scientists that we are to pick up from Mindelo, Sao Vicente on 2 February will arrive a few days early. Thus, we first sail onwards towards buoy *Laura* and plan to service buoy *Carmen* on the return voyage to Gran Canaria. On our way South we encounter some small fields of Sargassum sea weeds, which we sample for colleagues at NIOZ.

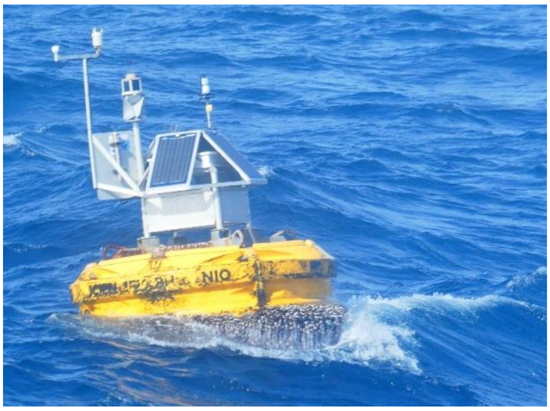


Figure 4.4: The sea state does not allow a safe recovery of buoy Carmen.

In the early morning of Tuesday 26 January, we reach the position of buoy *Laura*. We are fortunate that the sea state (8.4m/s wind) allows recovery of the buoy using the dinghy to attach the ropes to the buoy. This procedure goes really smooth; at $7.^{30}$ the dinghy is lowered into the water and at $8.^{20}$ the buoy is already standing on deck, safely secured to the ship!

Fig. 4.5: Buoy Laura *is safely tied to the ship with two lines that were attached to it from the dinghy.*

Also the remainder of buoy *Laura*'s recovery runs smoothly; at $13.^{00}$ the whole operation is completed with the recovery of the releases. In the afternoon we first deploy a CTD to 1200m, followed by deployment of a set of drifting traps. We then continue to recover mooring M1, which is completed on the same day at $20.^{00}$. The 'harvest' of sediment-trap mooring 20M1 is almost 100% success, after some corrections of wrong orders in the carrousels.

On Wednesday 27 January we start at $7.^{30}$ with the re-deployment of buoy Laura and at $9.^{00}$ the dummy buoy is set overboard. At $13.^{30}$ the anchor is deployed so that the dummy buoy can be replaced with the 'real' buoy. At $17.^{30}$ the whole operation is completed successfully.

The next morning (28/1) at $8.^{15}$ we start with the recovery of the drifting traps and continue with the recovery of the NMF test mooring. At $12.^{10}$ the release is on deck and during lunch we sail about 10nm to the position where the sediment-trap mooring M1 is going to be re-deployed. Shortly before 14.^{00} we start with the last deployment at this station, which we successfully finish at 16.^{25}, after which we head for Mindelo, Sao Vicente, Cape Verde Islands. The following days we are sailing through a yellow-ish haze and indeed the satellite images show some diffuse dust clouds over the area we are sailing through. All dust-collecting devices (N=3) indeed show orange colours, indicating Saharan dust.

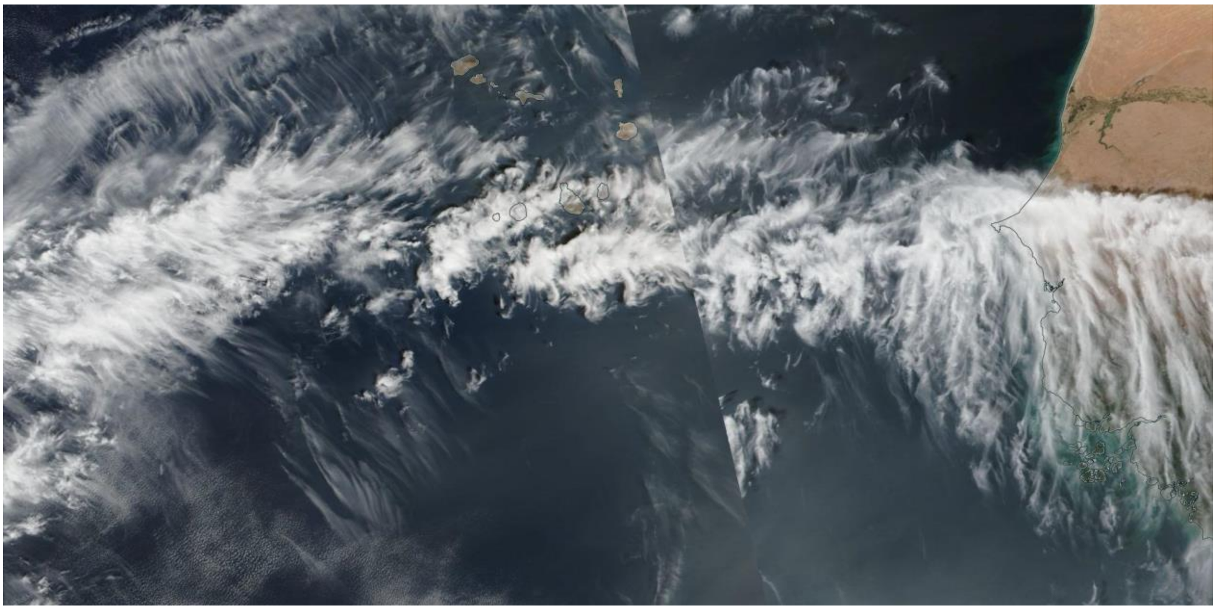


Figure 4.6: satellite (combined Aqua and Terra) images of the study area from NASA's Eosdis website. On 29 January 2021 a diffuse dust cloud can be seen (particularly at the edge of the two satellite overpasses) off the coast of Senegal.

En route to Mindelo, we receive the message that we do not have to pick up the three participants of the next cruise after all, so we set sail towards the area off Cape Blanc directly. This gives us the opportunity to sail a course that is directly 'upwind', meaning that there may be a downwind gradient visible in the dust samples that we take with both the high-volume dust collectors and the Omni dust collector. All three devices manage to acquire excellent samples.

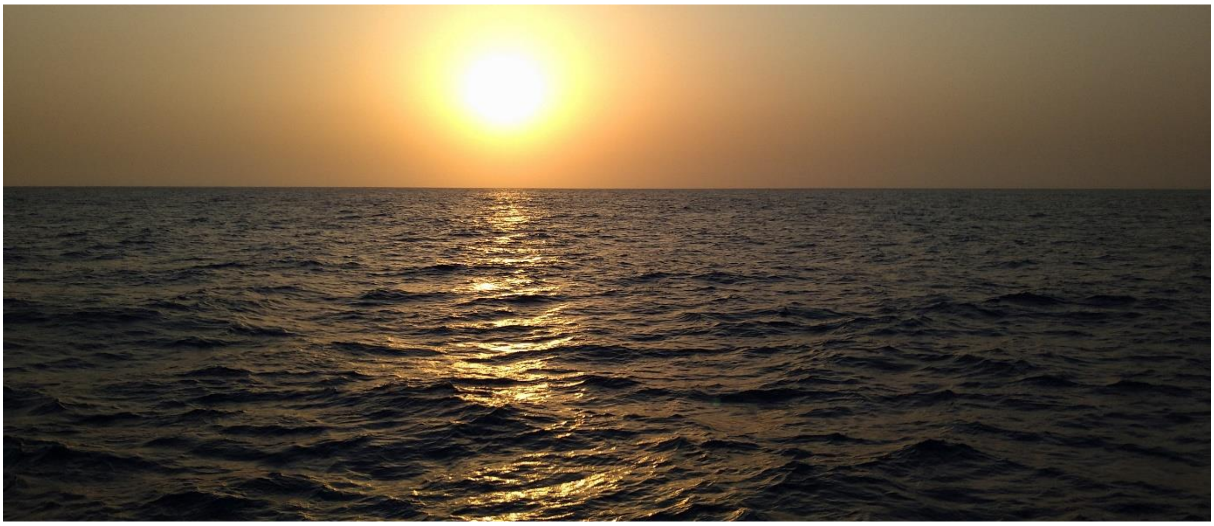


Figure 4.7: Particularly with low sun, it is clear that the lower atmosphere is loaded with dust.

*Figure 4.8: ♫ That's the way we like it ♫: good catch of the Miele dust collector (*letter*-sized cellulose acetate filter) collected during 24 hours on 29-30 January 2021.*

On Monday morning 1 February, the skies are bright and clear/clean; maybe a rain shower washed all the dust down?

In the evening (1/2) we deploy the drifting traps some five nautical miles West of buoy *Carmen*. During the night, the officers on the bridge already locate the buoy, even with a broken flashlight, so that in the morning of 2 February we can start with the recovery from the dinghy. Within half an hour, the two lines are attached to the buoy and within 15 minutes after the dinghy is back on deck, buoy Carmen is also standing on deck. At 13.20 the final bit of the mooring -the releases- are also on deck.
The same evening, at $18.^{30}$, we pick up the drifting traps, which have collected a nice set of samples.

On Wednesday 3 February at $7.^{30}$ we start the last action of this expedition: the re-deployment of buoy *Carmen* off the coast of Cape Blanc at T_{air}=21.0°C and T_{water}=21.4°C. At $10.^{35}$ the anchor goes in with a splash and at $15.^{00}$ the buoy is deployed successfully: on to Las Palmas de Gran Canaria! After a smooth transit with some long swell from the northwest we enter the port of Las Palmas on Saturday 6 February 2021.

Figure 4.9: RV Pelagia *entering the port of Las Palmas de Gran Canaria (Spain).*

5.1 Saharan-dust collection

Every year, 180Mton (180,000,000 kg!) Saharan dust are blown from the northwest African coast westward across the tropical North Atlantic Ocean (Yu et al., 2015). This material delivers nutrients and metals to the ocean, which potentially promote algal growth and thereby atmospheric CO_2 sequestration through the photosynthesis that these algae perform (e.g. Guerreiro et al., 2017). In addition, the dust particles play a role in the oceanic carbon cycle through ballasting of organic matter from the surface ocean towards the deep (e.g. Van der Jagt et al., 2018). We know very little as yet about aeolian transport and deposition processes of mineral-dust particles nor about the fertilisation and ballasting potential of mineral dust. Therefore, we are monitoring transport and deposition of Saharan dust using both dust-collecting buoys, which filter air underneath the main Saharan dust path out of Africa as well as moored sediment traps that collect material settling through the ocean. During the expeditions to service the monitoring instruments, we also collect atmospheric dust on board the ship using so-called high-volume samplers, a wet-dust/rain collector, and an *Omni* 3000 aerosol sampler (all in figure 5.1.1), which is designed to pump air through sterile water from which the microbiological content can be analysed.

During cruise 64PE482, we also collected dust *en route* using the aforementioned devices.

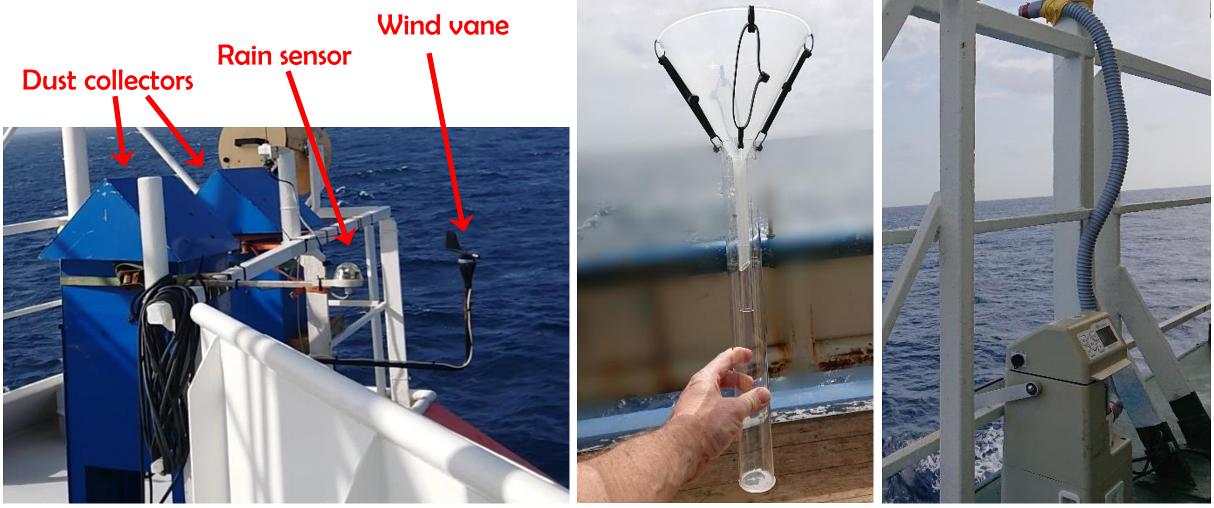


Figure 5.1.1: Dust collectors: high-volume | wet-dust/rain | Omni 3000

One of the largest risks with dust sampling is contamination. We routinely try to stay away from anthropogenic sources of aerosols by only sampling outside the 12-miles' zone. To prevent contamination from e.g., the ship's chimney, we use an intelligent wind vane, which causes the samplers to switch off whenever the wind is from outside a pre-defined angle. In addition, we direct the inlet of e.g., the *Omni* sampler away from the ship. A rain sensor is connected to the high-volume samplers to avoid water on the filters.

Typically, samples are collected on both cellulose-acetate filters (CA; for inorganic studies) and on glass-fibre filters (GF; for organic studies). However, only five of the available GF filters could be used, the rest appeared too brittle thanks to too extensive pre-combustion (?). Although the dust collectors were started outside the 12-miles' zone of Gran Canaria, thanks to the tailwind, the collectors would not switch on.

Figure 5.1.2: the wet-dust collector of buoy Laura *after one year.*

As a result, the first filter did not contain a lot of material although some light colouration can be observed (figure 5.1.3).

Figure 5.1.3: Cell. ac. filters were used on both dust collectors (Nilfisk & Miele) for samples 1, 3, 4, 7, 9.

Figure 5.1.4: High-volume dust collector samples #6 from Miele (cell. acetate, left) and Nilfisk (gf).

For details on the *en route* dust collection, please see figures 5.1.5 and 5.1.6 and tables 5.1.1. and 5.1.2.

Figure 5.1.5: Positions of all dust samples (N=10) collected with the high-volume dust collectors.

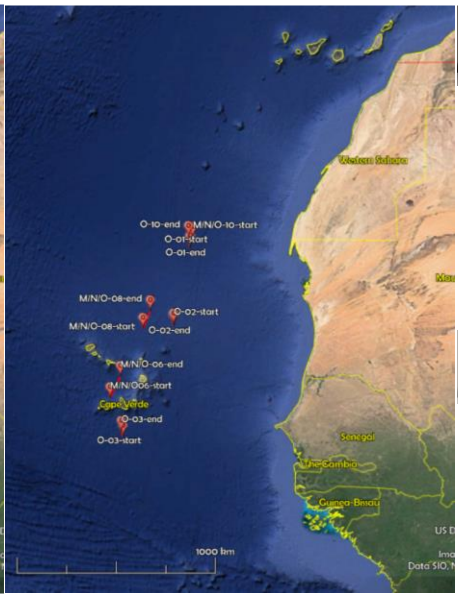


Figure 5.1.6: Positions of all dust samples (N=6) collected with the Omni sampler.

Figure 5.1.7: The two Omni samples #3 (top) and #6 that had a good yield. Samples (l), are compared with empty cartridges:

Table 5.1.1: Details of the dust filters (Miele-CA and Nilfisk-GF) collected during 64PE482

Filter nr	Type	Start-End	Time	Lat (°N)	Lon (°W)	Sampling time (min)	Total flow f³	Total flow m³	Remarks
1	CA	22/01/2021	08:45	24° 29.304'	18° 8.356'	Miele (CA)	314	12490.1	111056.2	Hardly any material, due to tail wind
	CA	26/01/2021	09:00	11° 22.420'	22° 57.690'	Nilfisk (CA)	316	9679.6	86614.7	
2	CA	26/01/2021	09:00	11° 22.420'	22° 57.690'	Miele (CA)	752	29892.9	636550.9	OK catch
	GF	27/01/2021	07:30	11° 18.500'	23° 1.590'	Nilfisk (GF)	752	22992.8	489617.5	
3	CA	27/01/2021	07:30	11° 18.500'	23° 1.590'	Miele (CA)	1126	44707.0	1425480.1	OK catch
	CA	28/01/2021	10:15	11° 29.060'	22° 50.130'	Nilfisk (CA)	1127	43964.2	1403040.9	
4	CA	28/01/2021	10:15	11° 29.060	22° 50.130'	Miele (CA)	1300	51654.5	1901510.6	Good catch
	CA	29/01/2021	08:55	13° 12.890'	23° 22.300'	Nilfisk (CA)	1299	50632.4	1862451.2	
5	CA	29/01/2021	08:55	13° 12.890'	23° 22.300'	Miele (CA)	1055	42220.6	1261316.6	Good catch
	GF	30/01/2021	08:30	15° 16.360'	24° 12.720'	Nilfisk (GF)	1056	32309.3	966137.0	
6	CA	30/01/2021	08:30	15° 16.360'	24° 12.720'	Miele (CA)	441	17675.2	220724.3	OK catch, given small sampling time
	GF	30/01/2021	16:50	16° 5.620'	23° 47.060'	Nilfisk (GF)	441	13498.1	168561.5	
7	CA	30/01/2021	16:50	16° 5.620'	23° 47.060'	Miele (CA)	1014	40612.0	1166110.1	OK catch
	CA	31/01/2021	10:00	17° 54.800'	22° 52.920'	Nilfisk (CA)	1012	40489.3	1160293.9	
8	CA	31/01/2021	10:00	17° 54.800'	22° 52.920'	Miele (CA)	428	17133.5	207652.5	Low catch, due to small sampling time
	GF	31/01/2021	17:30	18° 33.860'	22° 36.110'	Nilfisk (GF)	429	13111.9	159283.3	
9	CA	31/01/2021	18:00	18° 33.860'	22° 36.110'	Miele (CA)	1947	77981.1	4298685.0	OK catch
	CA	02/02/2021	08:00	21° 16.720'	20° 59.680'	Nilfisk (CA)	1944	77802.3	4283541.2	
10	CA	02/02/2021	12:30	21° 16.720'	20° 59.680'	Miele (CA)	907	36250.6	931043.0	Very low catch, no dust around....
	GF	03/02/2021	15:00	21° 14.966'	21° 3.160'	Nilfisk (GF)	907	27760.0	712974.5	

Table 5.1.2: Details of the dust samples collected with the Omni 3000 sampler during 64PE482

Cartridge nr	Type	Start-End	Time	Lat (°N)	Lon (°W)	Sampling time (min)	Remarks
1	Omni	23/01/2021	14:15	20° 57.017'	21° 4.913'	240	Low catch
		23/01/2021	18:15	20° 53.247'	21° 5.822'	240	Low catch
2	Omni	24/01/2021	09:00	18° 8.778'	21° 35.913'	180	Low catch
		24/01/2021	09:00	18° 4.714'	21° 35.937'	180	Low catch
3	Omni	29/01/2021	15:50	13° 53.311'	23° 38.075'	240	Good catch
		29/01/2021	19:50	14° 3.960'	23° 42.600'	240	Good catch
6	Omni	30/01/2021	16:50	15° 16.360'	24° 12.720'	440	Good catch
		30/01/2021	16:50	16° 5.620'	23° 47.060'	440	Good catch
8	Omni	31/01/2021	10:00	17° 54.800'	22° 52.920'	440	Low catch
		31/01/2021	17:30	18° 33.860'	22° 36.110'	440	Low catch
10	Omni	02/02/2021	12:30	21° 16.720'	20° 59.680'	440	Low catch
		02/02/2021	17:10	21° 17.750'	21° 10.810'	440	Low catch

Dust-sample handling and storage

- All cellulose acetate filters (N=15) from high-volume sampler *Miele* were folded twice and kept in individual sealed plastic bags at room temperature.
- One wet-dust sample, collected on buoy *Laura* for the entire deployment time was flushed into a container with exactly 500ml MQ water, sealed and stored at room temperature.
- All glass-fibre filters (N=5) from high-volume sampler *Nilfisk* were folded twice, wrapped in pre-combusted aluminium foil, and stored at -20°C;
- All cartridges (N=6) from the *Omni* 3000 sampler were packed into their original plastic wrapping and stored at -80°C.

5.2 Dust-collecting buoys

5.2.1 Recovery of buoys *20Laura* and *20Carmen*

Thanks to a too rough sea state, we could not recover buoy *Carmen* and had to proceed with buoy *Laura* first. On Tuesday 26 January we arrived at the buoy site early in the morning and started the recovery at 7.^{30} from the life boat. This went very smooth, a drone-recording of the recovery can be watched in the blog. Within an hour after launch of the life boat, at 8.^{20}, buoy *Laura* is secured to the deck. The only piece to be damaged during recovery is the plastic funnel of the wet-dust collector, which had turned very brittle thanks to UV radiation.

At $9.^{30}$ the releases are commanded to let go of the anchor and at $13.^{00}$ they are on deck. Twice daily, the buoys send home an eMail containing a status report on their position, meteorological conditions, filter number, pumping sessions, total air being pumped so far, and battery status. From these messages we had learnt already that there were some issues with buoy *Laura*, which had seemed to have stopped sampling after session 12 in July 2020. Also, we knew that a huge dust event had happened in the area in June 2020, and from the flow of buoy *Laura*, we could see that filter #10 potentially holds a lot of material, given the low amounts of air that had been pumped through the filter.

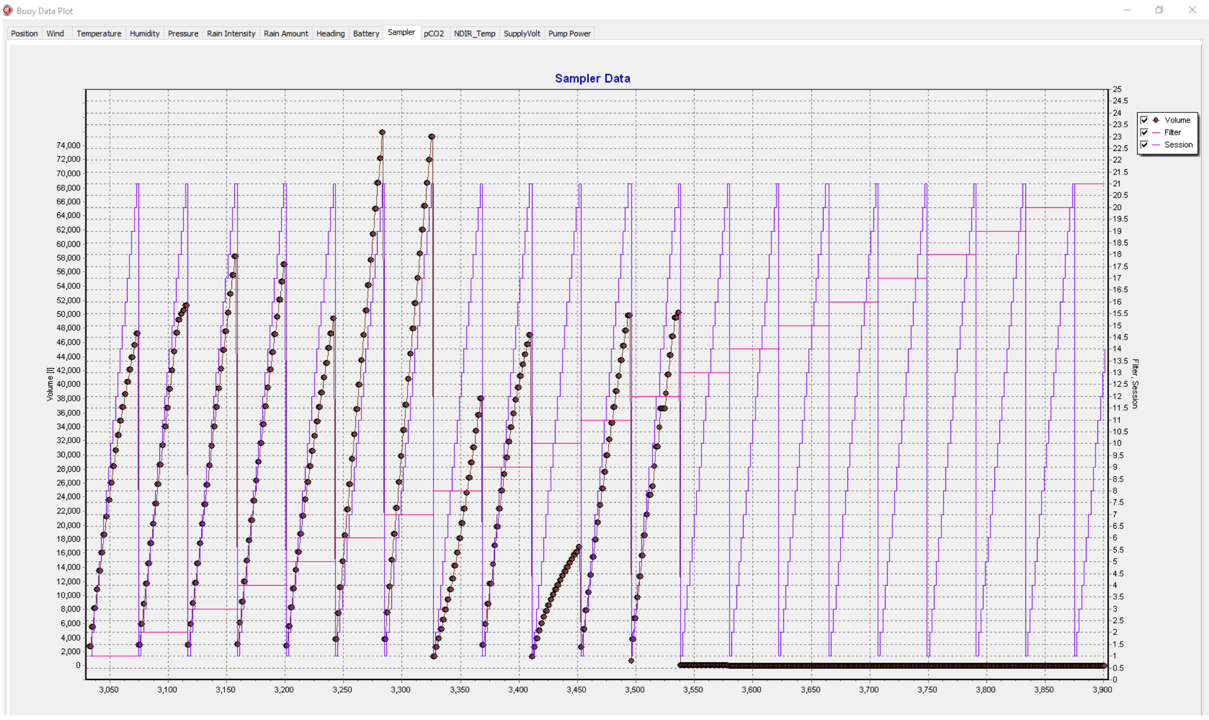


Figure 5.2.1: timeseries of buoy Laura *from November 2019 – January 2021, based on the eMail messages that the buoy had sent out twice daily and visualised by the parser that Bob Koster programmed. Left vertical axis:* volume of pumped air (l)*, plotted as brown dots; horizontal axis:* amount of sessions*; right vertical axis:* filter*, plotted as red line; and* session*, plotted as purple line.*

The (very) low flow could still mean that air was being pumped but not recorded (malfunctioning of the flow meter) or that indeed the pump itself was jammed. The latter turned out to be the case, unfortunately. We suspect that it is the electric power that is programmed to be delivered to the pump may have a too low threshold. Therefore, this amount of power is increased, hoping that for the next deployment the problem is fixed.
Of the N=12 filters that had passed under the buoy's inlet, only two were virtually virgin white (nrs 1 and 12), all other had some material on them. The filter that supposedly had caught Godzilla would have been nr 11, which indeed had a good amount of material. However, as appeared from figure 5.2.1, it was expected that filter nr 10 would be very rich in material, which was not the case after all. Filter two contained a bug (common moth, *Heterocera* [determined by David Tempelman, Bureau Waardenburg]) Two filters (nrs 8 and 9) had traces of water. The high flows of filter nrs 6 and 7 turned out to be the result of a leaking filter.

The MWAC sampler on buoy *20Laura* had a hole in the bottom, through which all material was washed out. The prototype wet-dust collector has worked well, see figure 5.1.2.

The CTD on buoy 20Laura was programmed to measure every two hours. The series started at deployment during expedition 64PE464 on 18 November 2019 yet stopped prematurely and unexpectedly on 19 August 2020. The battery turned out to be flat.

On Tuesday 2 February 2021 we approach buoy *Carmen* at sunrise. Despite that the flashlight was broken, she was clearly visible on the radar. Fortunately, the sea state now is calm enough to allow recovery of the buoy using the life boat. She turned out to be completely overgrown with gooseneck barnacles.

Timeline of the recovery: $8.^{10}$ – deploy lifeboat; $8.^{40}$ – life boat back on deck; $8.^{55}$ – buoy on deck; $13.^{20}$ – releases on deck (after 25-minute lunch break).

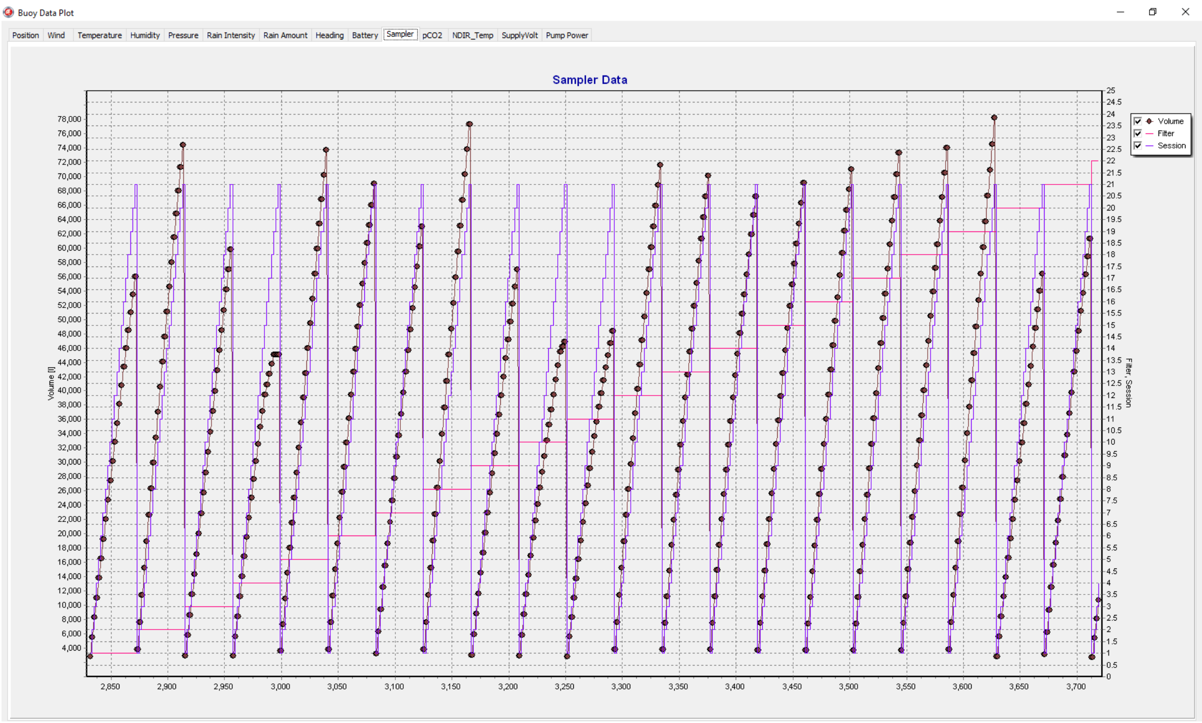


Figure 5.2.2: timeseries of buoy Carmen *from November 2019 – February 2021, based on the eMail messages that the buoy had sent out twice daily and visualised by the parser that Bob Koster programmed. Left vertical axis:* volume of pumped air (l)*, plotted as brown dots; horizontal axis:* amount of sessions*; right vertical axis:* filter*, plotted as red line; and* session*, plotted as purple line.*

From the eMail messages, we knew that the series *20Carmen* could be flawless and from the patterns in the flow per sample, some filters could contain considerable amounts of dust. However, series *20Carmen* seems to be characterised by mainly wet filters. About half of the filters (of the total of N=22) show some traces of water, some were completely transparent. The addition of water causes the air flow to decrease the same way as loading with dust particles would. Nevertheless, about half of the filters contain nice amounts of dust, including a tiny bug (dust lice, *Psocoptera* [determined by David Tempelman, Bureau Waardenburg]) on filter nr 3.

Time series *20Carmen* resulted in eight filters containing significant amounts of dust, some of which also showed traces of water, or aggregates caused by water on the filter. Fortunately, the polycarbonate filters that we use, can stand water.

The MWAC sampler on buoy *20Carmen* had been decapitated, either during deployment in 2019 or during recovery in 2021…

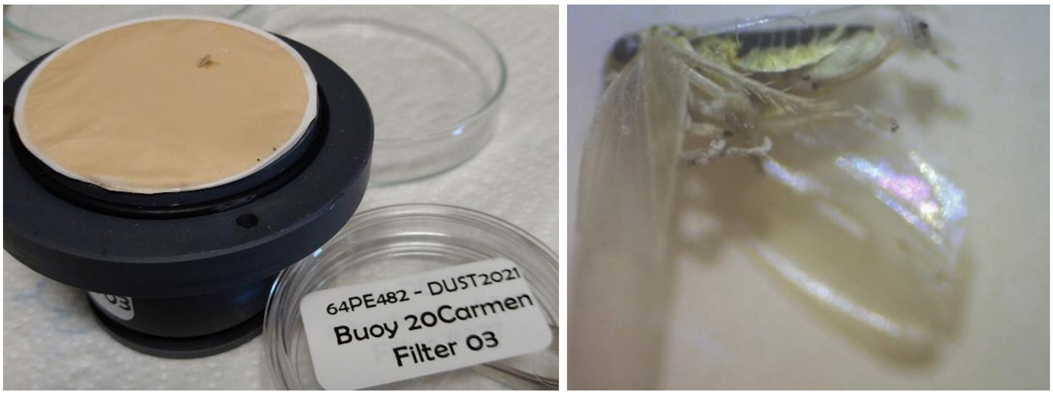


Figure 5.2.3: Example of a filter from buoy Carmen *that is loaded with dust, in addition to a tiny bug. The close-up photo was made with a Traveler microscope at 60x magnification.*

Figure 5.2.4: Example of filters from buoy Carmen *that contain traces of water. Filter nr 6 (l) shows dust clumped together as a result of water, which also turned the polycarbonate filter to turn transparent. Filter nr 20 is less transparent and shows a light orange-ish colouration from dust, in addition to a wet O-ring, potentially having picked up water through contact with the chimney.*

The CTD on buoy *20Carmen* was programmed to measure every hour. The series started at deployment during expedition 64PE464 on 14 November 2019 yet stopped prematurely and unexpectedly on 19 September 2020. The battery turned out to be flat....

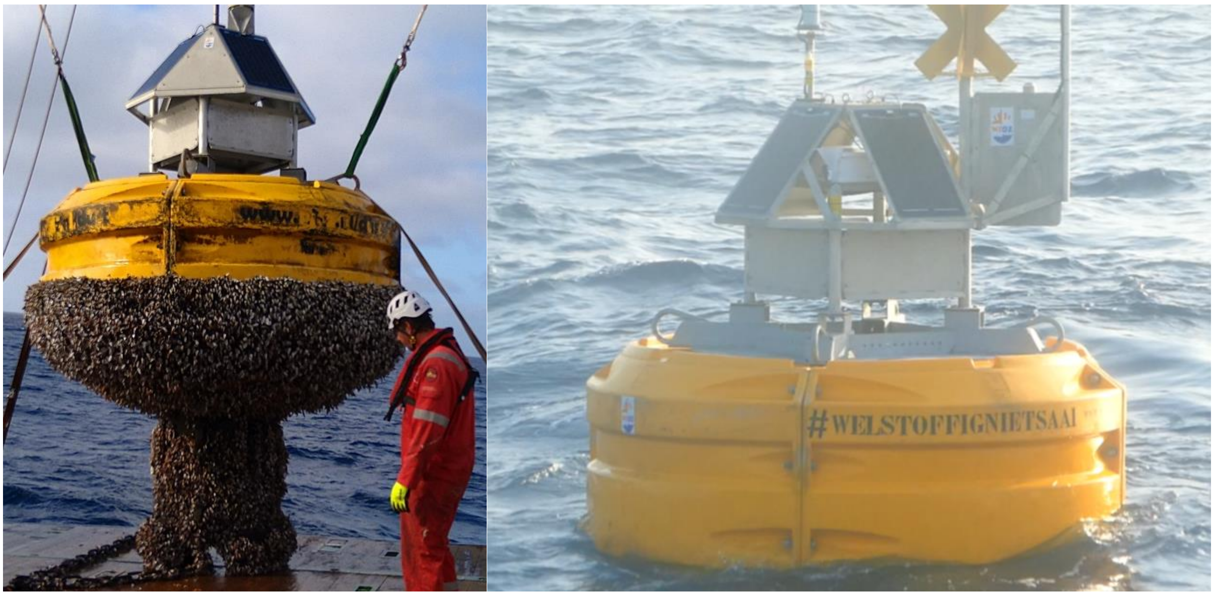


Figure 5.2.5: Buoy Carmen *right after recovery from the eutrophic upwelling region off Cape Blanc, Mauritania and nicely clean-shaven directly after re-deployment.*

5.2.2 Deployment of buoys *21Carmen* and *21Laura*

Both dust-collecting buoys were deployed successfully and programmed to sample at a 20-day resolution initially. In the month July 2021 the buoys will be sampling and measuring for the ASKOS campaign, which is dedicated to calibrating the ALADIN wind lidar on the AEOLUS mission with on-the-ground / over-the-ocean data. Depending on how many filters have been used for the ASKOS campaign, in August 2021 the 20-day resolution will be resumed again with an increased resolution of 10 days until recovery in November 2021 during the SIPA expedition (MARUM-Bremen) onboard RV *Meteor*. See table 5.2.1 for details on the exact position of the buoys and details on the timing of the sampling programs. Sketches of the moorings are provided in the Appendices.

Table 5.2.1: key data of dust-collecting buoys Carmen *and* Laura *deployed during 64PE482*

Instrument	Start date	Lat (° 'N)	Lon (° 'E)	End date	Nr cups	Interval
Buoy *21Laura*	28 Jan 2021	11°22.152'	22°58.390'	4 Dec 2021	24	20/10 days
Buoy *21Carmen*	3 Feb 2021	21°14.945'	21°3.140'	11 Dec 2021	24	20/10 days

5.3 High-resolution sediment-trap mooring M1

5.3.1 Recovery of sediment-trap mooring 20M1

On Tuesday 26 January 2021, high-resolution sediment-trap mooring M1 was released at $17.^{30}$. At $18.^{00}$ the smartie was 'caught' and at $20.^{00}$ the releases were lying on deck. All three sediment traps had functioned fine and all bottles contained some material but the bottle order turned out to be flawed as bottles had been inserted into the carousels in the wrong order. The order was restored and bottles were re-labelled before removal from the carousels.

Lower trap @1250m

- The lower trap contained two carousels of which the lower one was set up correctly.
- This lower carousel with 20 bottles had been sampling between 22 November 2019 – 10 February 2020 at a four-day resolution.
- Of the upper carousel, the numbering was flawed/in the wrong direction. However, this time the last position was left empty correctly so that a simple relabelling of bottles 39-21 to 21-39 was enough to correct the error.
- The upper carousel had been sampling from 10 February 2020 – 26 April 2020 at a four-day resolution.

Figure 5.3.1: Five bottles from the lower trap showing the catch of four days per bottle.

Middle trap @1150m

- The middle trap contained two carousels of which the lower one was set up correctly.
- This lower carousel with 20 bottles had been sampling between 26 April 2020 – 15 July 2021 at a four-day resolution.
- Of the upper carousel, the numbering was flawed/in the wrong direction and shifted by one position. As a result, bottle nr 21 was skipped and a bottle (nr 40) was placed in the position that otherwise would be left empty to allow the funnel to drain during recovery. As a result, bottle nr 40 has been sampling since 12 November 2020 until recovery: 75 days.
- The upper carousel had been sampling from 19 July 2020 – 16 August 2020 on a 4-day resolution. Thanks to the omission of bottle nr 21, there is a 4-day gap in the time series between 15 -19 July 2020. From 16 August 2020 – 12 November 2020, this carousel had been sampling at an eight-day resolution.

Figure 5.3.2: Four bottles from the middle trap, upper carousel showing the catch of eight days per bottle for nrs 37-39 and the catch of 75 days of sedimentation in bottle nr 40.

Upper trap @1050m

- During the previous cruise (64PE464 in November 2019) we had one broken sediment-trap motor. Therefore, the upper trap (at 1050m) was equipped with one carousel only.
- In accordance with the schedule, bottle nr 10 of this carousel was still sampling during recovery. This bottle had opened at 23 January and so contains three days of sampling.
- The upper trap had been sampling since 12 November 2020 at an eight-day resolution.

The data loggers of the depth, tilt, fluorescence and turbidity attached to the upper trap had worked flawlessly. Depth and tilt did not show any deviation from the vertical larger than 1°. Particularly the turbidity time series shows some spikes, indicating larger amounts of settling particles, which shall be compared with the fluxes in the sediment traps.
The seacat CTD that was also attached to the upper trap had sampled at a one-hour interval and worked fine. Its data show that the sediment trap that was supposed to be at 1050m water depth, has actually sampled at 1490m water depth. Accordingly, the middle trap was at 1590m (not 1150m) and the lower trap at 1690m (not 1250m).

5.3.2 Deployment of sediment-trap mooring 21M1

On Thursday 28 January 2021, re-deployment of high-resolution sediment-trap mooring 21M1 was initiated at $13.^{55}$. At $16.^{25}$ the anchor was deployed at more or less the same position as she used to be since 2012 [11°28.51'N | 22°42.48'W | wd 5082m]. See sketch of mooring in the appendix for details.

Using the CTD-rosette, sea water was taken from 1250m water depth to fill the bottles of all carousels. Unfortunately, during the preparations of the biocide for one trap in mooring 21M1, an inexplicable precipitation formed. Therefore, there was not enough biocide left to add to the two carousels of the upper trap. Bottles nr 11 – 20 could be recycled. As a result, bottles nr 1 – 10 and 21 – 39 do not contain any biocide, bottles 11 – 20 do.
All bottles in the middle and lower trap do contain a mixture of $HgCl_2$ and Borax.

Thanks to the fact that the next servicing of the high-resolution mooring will take place during the SIPA cruise in November 2021, we could set the sampling of the lower and middle traps to two days, the upper trap will sample at a four-day resolution. For the detailed sampling scheme of mooring 21M1, see Appendix 7.

5.4 Drifting traps

Two deployments of the drifting traps were made, in the vicinities of the two dust-collecting buoys. Around buoy *Laura*, there was some Saharan dust around, in the vicinity of buoy *Carmen*, there was none. The traps were filled with filtered and densified [0.7μm glass-fibre filter] sea water. 250g NaCl was dissolved in 6L of filtered sea water, of which 500ml was poured gently into the tubes. Three sets of four tubes were prepared to be suspended at water depths of 100m, 200m and 400m. Each set contained one petri dish with Tissue-Tek® O.C.T.™ Compound, which is a gel that does not change composition (form crystals) when frozen/thawed even several times. Fragile marine-snow particles, that would otherwise fall apart, sink into the gel and are thus preserved for further study.

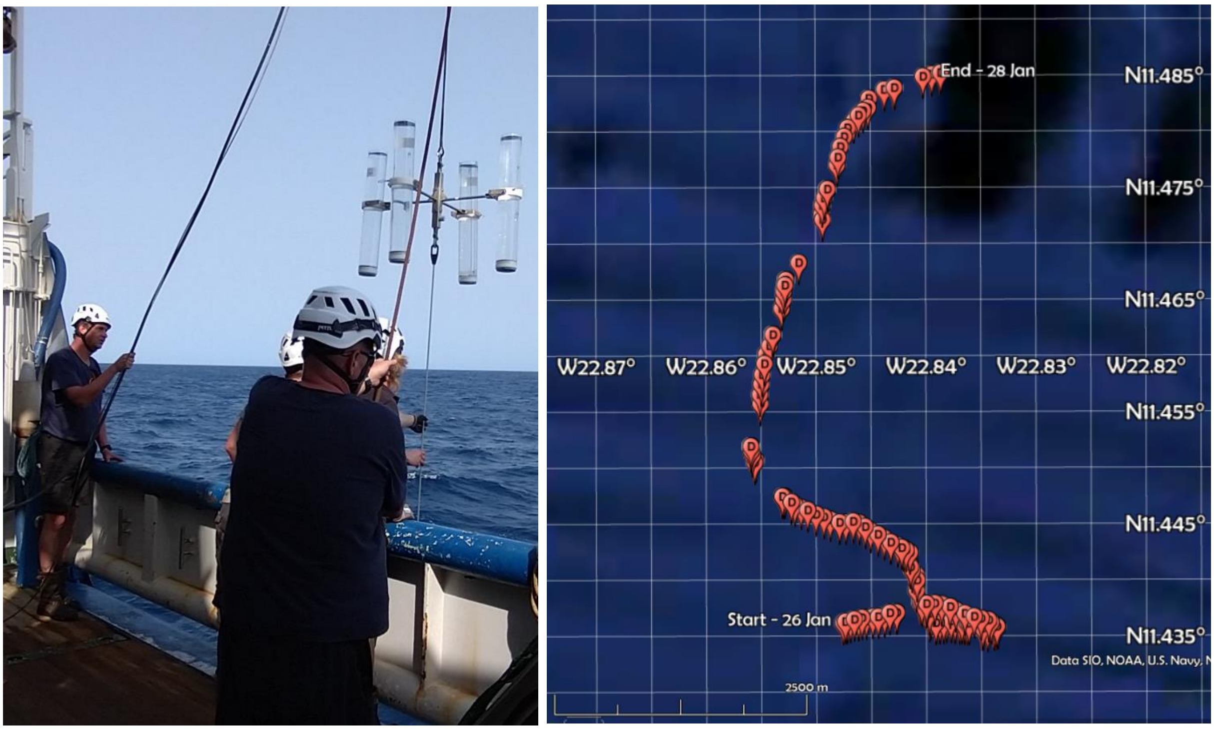


Figure 5.4.1: Drifting traps were deployed in the vicinity of buoy Laura *on 26 January 2021. During the 42 hours that the traps were drifting, they covered a distance of less than 3nm, ~5.5km.*

Water of the remaining three tubes per depth was first siphoned off until about 1L of water remained in the tube. This water was filtered over pre-weighed 0.4μm polycarbonate filters.

The gels were stored at -80°C, the filters were stored in petri-slides at 6°C.

Figure 5.4.2: Gels with marine-snow particles and other settling matter collected around M1 at 100m, 200m, and 400m (L2R).

The first set of drifting traps was deployed on Tuesday 26 January 2021 at $15.^{30}$ and recovered on Thursday 28 January 2021 at $9.^{30}$, meaning that they have been collecting settling particles for a period of about 42 hours. During this time they drifted about 3 nm (~5.5 km) towards the north (figure 5.4.1).

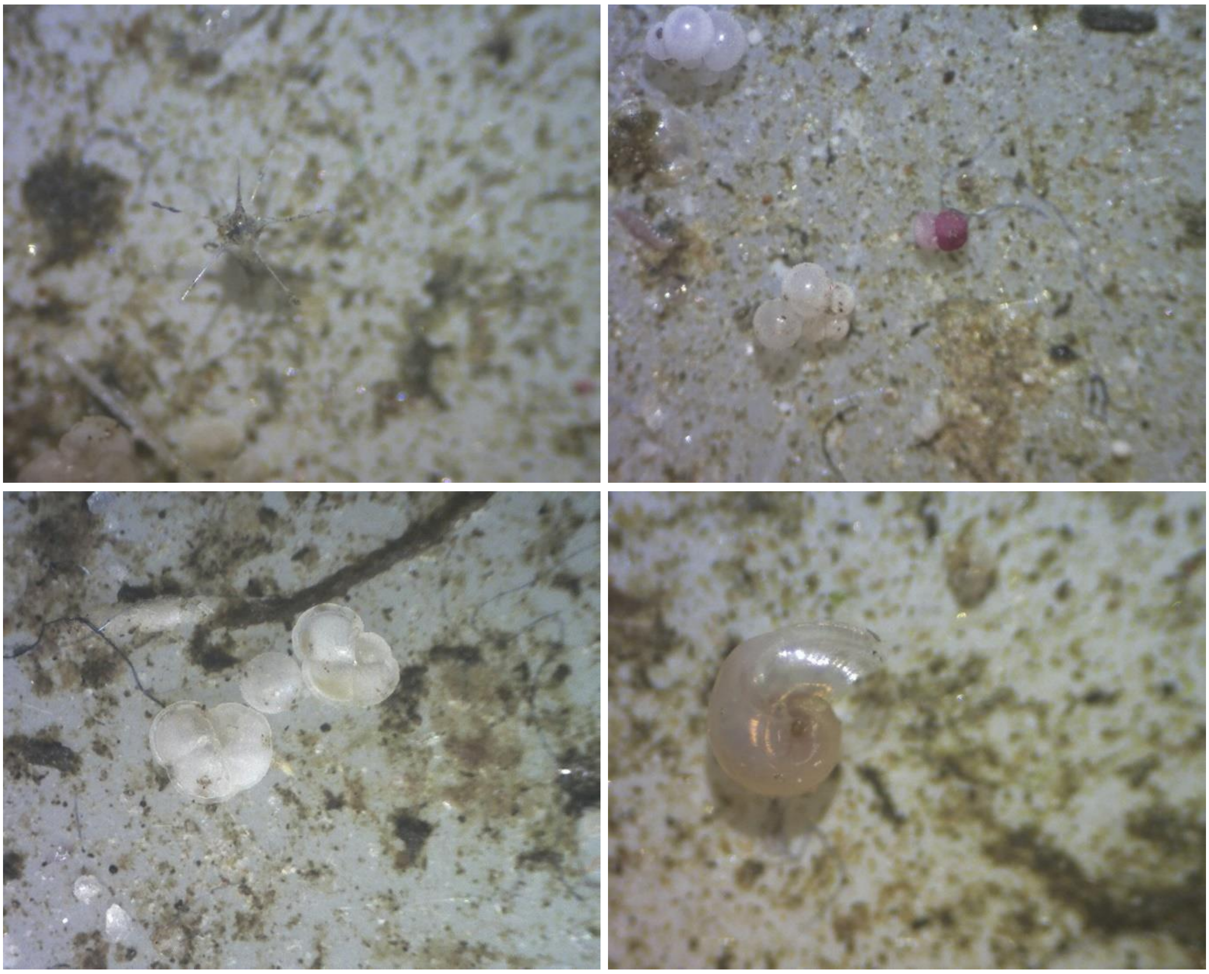


Figure 5.4.3: 'Creatures big and small', collected in the tubes of the drifting traps. All pictures taken with a Traveler microscope, at a 60x magnification.

The second set of drifting traps was deployed on Monday 1 February 2021 at $20.^{45}$ and recovered on Tuesday 2 February 2021 at $18.^{30}$, meaning that they have been collecting settling particles for a period of about 22 hours. During this time they drifted about 4¼ nm (~8 km) towards the northwest (figure 5.4.4).

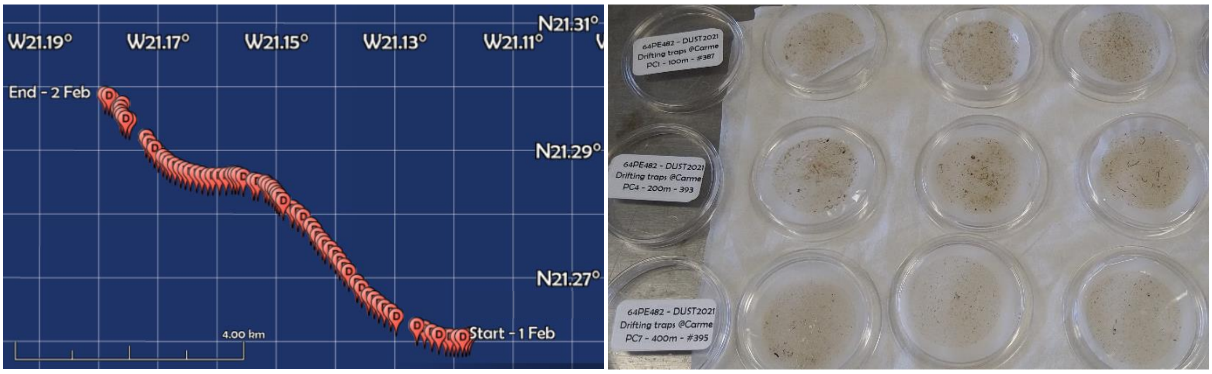
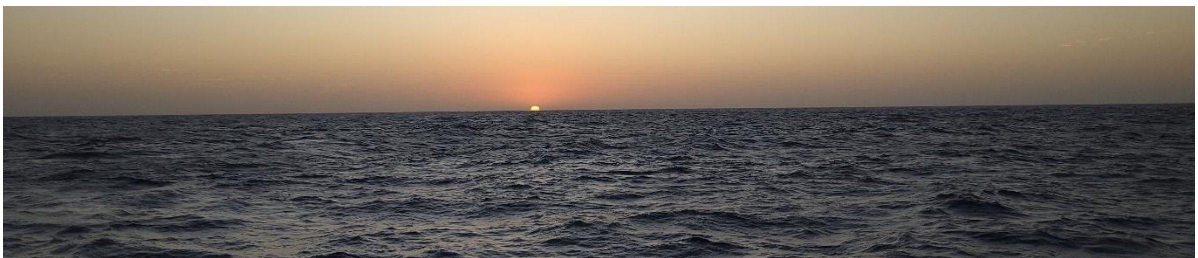


Figure 5.4.4: Drifting traps were deployed in the vicinity of buoy Carmen *on 1 February 2021. During the ~22 hours that the traps were drifting, they covered a distance of about 4¼nm, ~8km. The filters shown on the right illustrate the decreasing particle density with depth.*

6 *Acknowledgements*

Our sincere thanks go to Master Len Bliemer and his crew for the friendly cooperative atmosphere during the entire cruise as well as their competent technical assistance during all operations. You made us really feel at home!

Figure 6.1: the 64PE482 dreamteam. Standing L2R: Barry, Len, Jolanda, Stephan, Alex, Marcel, Jan-Dirk, Chiel, Martin, Bob, Peter, Jan-Berend. Sitting R2L: Aleks, Roel, Bert



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