METEOR-Berichte

Scales of population dynamics, ecology and diversity of planktonic foraminifera and their relationship to particle flux in the eastern tropical Atlantic

Cruise No. M140

11.8.2017 – 5.9.2017
Mindelo (Cabo Verde) – Las Palmas (Spain)

FORAMFLUX

Michal Kucera, Michael Siccha, Raphaël Morard, Lukas Jonkers, Christiane Schmidt, Philipp Munz, Jeroen Groeneveld, Gerhard Fischer, Götz Ruhland, Marco Klann, Morten Iversen, Christian Konrad, Jan-Berend Stuut, Geert-Jan Brummer, Bob Koster, Yvo Witte, Jan-Dirk de Visser, Manuel Weinkauf, Haruka Takagi, Julie Meilland, Ulrike Baranowski, Marina Rillo, Jacqueline Bertlich, Theresa Fritz-Endres, Gurjit Theara, Adrian Baumeister, Paul Debray, Jasper Leonard Magerl and Andreas Raeke

Michal Kucera & Michael Siccha
MARUM – Zentrum für Marine Umweltwissenschaften der Universität Bremen

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1 Summary

Cruise M140 combined sampling of plankton, mineral dust and other particles in the water column with recovery of data and samples from long-term observational platforms (sediment traps and dust-collecting buoys). The aim of the cruise was to provide new observations to improve our understanding of the ecology of planktonic foraminifera as important carriers of paleoceanographic proxies and to investigate how mineral dust deposition and the production of marine snow and biogenic particle ballast vary in space and time and how they affect the marine biological pump. To this end, the cruise followed a transect in the central western Atlantic between oligotrophic waters of the subtropical gyre and the productive coastal waters off Mauretania affected by coastal upwelling. To characterise population dynamics, ecology and physiology of planktonic foraminifera, we obtained a series of fourteen vertically resolved plankton net profiles along the cruise track, together with profiles of physical and chemical properties of the ambient water masses. Live foraminifera extracted from these profiles were used to quantify photosynthetic activity of selected species and determine their photoadaptation. High-resolution spatial and temporal sampling of the upper 300 m over 24 hours was carried out at two locations (recovering 41 and 46 vertical profiles), allowing the characterisation of patchiness and daily vertical migration of planktonic foraminifera. Moorings with sediment traps monitoring the seasonal and short-term variability of particle fluxes and buoys monitoring atmospheric dust deposition in the region were successfully recovered in the central Atlantic (M3), south of Cabo Verde (M1) and off Mauretania (CB and CBi) and redeployed in the latter two regions to continue the monitoring. Short-term variability of sizes and types of sinking particles in the water column were characterised in each of the monitoring regions with drifting sediment traps and in the Cape Blanc region off Mauretania also with continuous vertical particle camera profile. All aims of the cruise have been met – the plankton sampling and particle characterization studies were carried out successfully and all moorings and buoys could be recovered and/or redeployed as planned.

2 Participants

1.	Michal Kucera	Chief Scientist 1st Leg	MARUM
2.	Michael Siccha	Chief Scientist 2nd Leg	MARUM
3.	Raphaël Morard	Plankton genetics	MARUM
4.	Lukas Jonkers	Sediment traps	MARUM
5.	Christiane Schmidt	Photophysiology	MARUM
6.	Philipp Munz	Multi-Plankton-Sampler	Senckenberg/UniTü
7.	Jeroen Groeneveld	Water chemistry	MARUM
8.	Gerhard Fischer	Sediment traps	MARUM
9.	Götz Ruhland	Moorings	MARUM
10.	Marco Klann	Moorings	MARUM
11.	Morten Iversen	Particle camera	MARUM / AWI
12.	Christian Konrad	Particle camera	MARUM / AWI
13.	Jan-Berend Stuut	Dust buoys	NIOZ / MARUM
14.	Geert-Jan Brummer	Sediment traps	NIOZ / VU
15.	Bob Koster	Dust buoys	NIOZ
16.	Yvo Witte	Moorings	NIOZ
17.	Jan-Dirk de Visser	Moorings	NIOZ
18.	Manuel Weinkauf	Plankton analysis	UGeneva
19.	Haruka Takagi	Photophysiology	AORI
20.	Julie Meilland	Plankton analysis	Ocean Zoom
21.	Ulrike Baranowski	Plankton analysis	GEES
22.	Marina Rillo	Plankton analysis	MARUM
23.	Jacqueline Bertlich	Water chemistry	GEOMAR
24.	Theresa Fritz-Endres	Plankton analysis	CEOAS
25.	Gurjit Theara	Plankton analysis	MARUM
26.	Adrian Baumeister	Plankton analysis	MARUM
27.	Paul Debray	Plankton analysis	MARUM
28.	Jasper Leonard Magerl	Plankton analysis	Senckenberg/UniTü
29.	Andreas Raeke	Weather technician	DWD

AORI
Atmosphere and Ocean Research Institute, The University of Tokyo
5-1-5, Kashiwanoha, Kashiwa, Chiba 277-8564 / Japan
www.aori.u-tokyo.ac.jp/english

AWI
Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar und Meeresforschung
Am Alten Hafen 26, D-27568 Bremerhaven / Germany
www.awi.de

CEOAS
College of Earth, Ocean, and Atmospheric Sciences, Oregon State University
104 CEOAS Administration Building, Corvallis, OR 97331-5503 / USA
www.ceoas.oregonstate.edu

DWD
Deutscher Wetterdienst, Seeschifffahrtsberatung
Bernhard-Nocht-Straße 76, 20359 Hamburg / Germany
www.dwd.de

GEES
School of Geography, Earth and Environmental Sciences, University of Birmingham
Edgbaston, Birmingham B15 2TT / UK
www.birminghma.ac.uk/schools/gees

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel
Wishhofstraße 1-3, D-24148 Kiel / Germany
www.geomar.de

Senckenberg Centre for Human Evolution and Palaeoenvironment
at the University of Tübingen
Hölderlinstraße 12, D-72074 Tübingen / Germany
www.geo.uni-tuebingen.de

MARUM
Zentrum für Marine Umweltwissenschaften, Universität Bremen
Leobener Straße 8, D-28359 Bremen / Germany
www.marum.de

NIOZ
Royal Netherlands Institute of Sea Research in cooperation with Utrecht University
PO Box 59, 1790 AB Den Burg (Texel) / The Netherlands
www.nioz.nl

Ocean Zoom
UFR Sciences et Techniques
2 rue de la Houssinière, BP 92208, 44322 Nantes Cedex 3 / France
www.oceanzoom.fr

UGeneva
University of Geneva, Faculty of Science, Department of Earth Sciences
12 Rue de Maraichers, 1205 Geneve / Switzerland
www.unige.ch

VU
Department of Earth Sciences, Vrije Universiteit Amsterdam
de Boelelaan 1085, 1081HV Amsterdam / The Netherlands
science.vu.nl/en/research/earth-sciences

3 Research program

3.1 Plankton ecology

Much of what we know about the state of our planet in the geological past, in particular the chemistry, temperature and circulation of its oceans, has been derived from the study of microscopic shells of planktonic foraminifera (Kucera, 2007). Because the biomineralisation of foraminifera is highly regulated by the organism, chemical signatures in the calcite shell are often offset from inorganic equilibria and their application as proxies requires species-specific calibration and a detailed understanding of the time and depth of calcification of each species. Despite their obvious importance ofr the interpretation of paleoceanographic proxies, most of the essential aspects of the ecology of planktonic foraminifera species still remain poorly constrained. Many of the unknown aspects of planktonic foraminifera ecology are related to the lack of understanding of factors that govern their abundance and distribution in the water column. This issue is not limited to foraminifera. The spatial and temporal heterogeneity (patchiness) of plankton is crucial for the understanding and modelling of plankton population dynamics in general. Although the distribution of planktonic foraminifera species in terms of biogeographic provinces is well constrained, very little is known about the variability on smaller scales. Various concepts about the lifecycle of planktonic foraminifera exits in the literature (Hemleben et al., 1989), but most of them have never been tested rigorously. Amongst these are concepts of synchronised (lunar) reproduction, diel vertical migration and an ontogenetic vertical migration (Hemleben et al., 1989).

Planktonic foraminifera occupy an intermediate position between passively floating small phytoplankton and motile zooplankton. They have no active means of locomotion, but may be able to control their buoyancy; they are heterotrophic but many species harbour photosynthetically active symbionts which render them as facultative autotrophs. It is unknown how vertical habitat depths and its variability among individual species are linked to the existence of cryptic diversity and the occurrence of symbionts and their photophysiology have been studied only in a handful of species. The SCOR/IGBP Working Group 138 'Modern Planktic Foraminifera and Ocean Changes' has been established in 2011 to stimulate research in this field. The working group identified research priorities that have been used to design the research programme of this cruise. The principal aim of FORAMFLUX was to provide data and samples that are needed to investigate the extent and scale of population patchiness, ontogenetic and diel vertical migration, synchronisation of reproduction, symbiont presence and physiology and the extent of genetic diversity in the group. To meet this goal, we followed an approach combining observations from sediment traps, plankton samples and on-board experiments.

Sampling of the water column by filtration and by plankton tows was used to determine horizontal and vertical distribution, diversity and physiology of planktonic foraminifera species. The sampling was carried out using a vertically resolving plankton sampler (multiple closing plankton net) along transects and in a full-day continuous sampling scheme replicated at two stations. Observations on the plankton were combined with measurements of physical water properties and water sampling to characterise the hydrography at the sampling stations. Plankton samples have been processed during the cruise and foraminifera have been be fixed for genetic analysis, TEM study of digestive content and symbiont content and the photosynthetic activity of the symbionts has been measured on board. Next to the seasonal variation of species flux, the existence of synchronised reproduction and the extent of short-term variability in planktonic foraminifera flux was studied by analysis of samples from sediment traps, deployed in a unique design allowing high-resolution coverage of flux variability across the seasonal cycle.

3.2 Dust monitoring

Each year, huge quantities of dust are blown westward from Northwest Africa. About 80% of this dust flux end up in the Atlantic Ocean (Yu et al., 2015). Mineral dust may act as a fertiliser for marine plankton and ballast particles carrying organic material to the sea floor, thus affecting the marine carbon cycle. The dust-monitoring program of the cruise is part of a long-term effort to understand modern mineral dust emission, transport, and deposition in order to assess its role(s) in climate feedback mechanisms, to provide data for climate models, and to interpret dust deposits in marine sediment records with respect to past-climate reconstructions. As the Sahara is by far the largest source of dust on the planet, two projects were designed to monitor Saharan dust along a transatlantic transect between the African coast and Barbados at 12ºN: TRAFFIC (funded by NWO, the Dutch national science foundation) and DUSTTRAFFIC (funded by an ERC starting grant). The projects aim to monitor Saharan dust from source to sink across a distance of about 4000km (Figure 3.1). The projects are linked to ongoing dust-monitoring projects like the ~30-year long CB and CBi recording stations off Cape Blanc, Mauritania, and the ~50-year long dust-monitoring station on Barbados, by Prof. Prospero in Miami. For more information on the projects set up, initial results and publications, please see: www.nioz.nl/dust.

Until now, the transatlantic data set contains three complete observation years for the whole transect. The FORAMFLUX cruise facilitated the recovery of moored sediment traps and dust-collecting boys with data for the 2016/2017 season. A combination of the dust monitoring program with studies of foraminifera flux offered the possibility to extend the sampling at two stations until autumn 2018. Station M3 at 12ºN/37ºW consists of a mooring with two sediment traps and dust-collecting buoy Michelle. This mooring at this station has been successfully recovered and monitoring at this station is discontinued. Mooring M1 at 12°N/37°W consists of three sediment traps and dust-collecting buoy Laura. The sediment traps have been collecting settling material at an unprecedented high resolution of four days between April 2016 and August 2017. This unique sediment trap mooring was redeployed at the same position and is programmed to continue until October 2018. At station CB at 21°N/21°W, our array contains dust-collecting buoy Carmen in

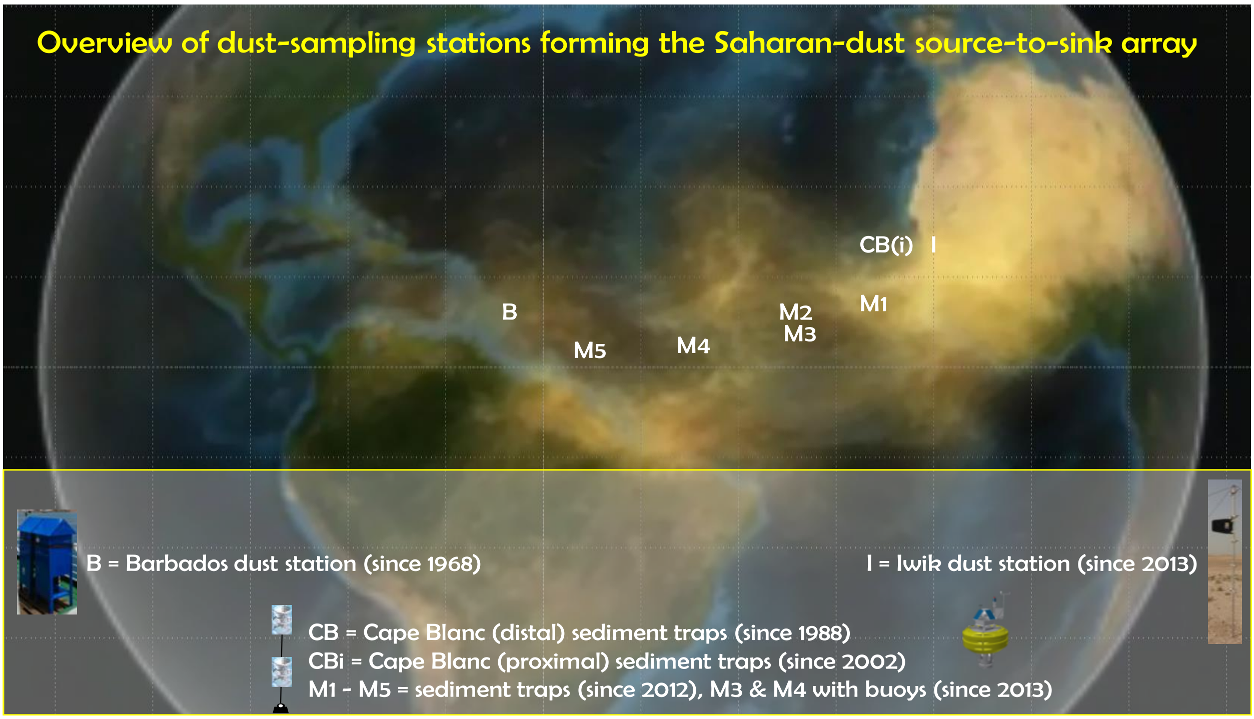

Figure 3.1: *Position of the dust monitoring stations M3, M1 and CB visited during the FORAMFLUX cruise.*

addition to the moored sediment traps operated by MARUM. Buoy Carmen has been serviced and re-deployed. Finally, underway sampling of Saharan dust has been been carried out using so-called Hi-Volume air samplers, a passive rain collector as well drifting traps.

3.3 Particle studies

Understanding the dynamics of the flux of planktonic foraminiferal shells and mineral dust to the sea floor has significant consequences for the assessment of their role in mediating export production. Through ballasting marine aggregates, foraminifera and dust may play an important role in the biological pump. The formation and sinking of organic aggregates, such as marine snow and fecal pellets, drive the biological carbon pump via export of organic matter to the deep ocean. Previous field studies off Cape Blanc showed that the export of organic carbon was driven by small and fast-settling aggregates ballasted by coccoliths and fine-grained dust from the Sahara (Fischer and Karakas, 2009). However, most studies on the role of ballast for export of organic carbon have focused on coccolithophorids as a source of carbonate (Iversen and Ploug, 2010) and overlooked the contribution from foraminifera, which contribute a large part of the calcium carbonate exported to the deep sea.
During FORAMFLUX, short-term particle flux and particle composition in the water column were studied using drifting particle traps and in situ cameras. Most of these observations were made in the Cape Blanc region. This region is part of the upwelling cell off Mauretania. Such coastal upwelling regimes are the most productive areas of the oceans and play a key role in the modern global carbon cycle, climate and ecosystem change. Next to the short-term particle flux studies, there exist two long-term mass flux time series from moored sediment traps. One at the mesotrophic study site CB off Cape Blanc, Mauritania (since 1988; Fischer et al., 2016) and a second from the eutrophic site CBi (since 2003). Both long-term sediment trap sites are situated within the 'giant Cape Blanc filament and were designed to monitor the long term (subdecadal to decadal) flux variability as well as potential trends in carbon fluxes due to Atlantic climatic forcings or anthropogenic changes in upwelling intensity (Bakun, 1990). FORAMFLUX provided an opportunity to service both moorings, extending the time series to autumn 2018. The CB mooring has been equipped with additional trap to facilitate a spatial replication of the unique high-resolution sampling design used in mooring site M1.

4 Narrative of the cruise

On Friday, August 11, RV METEOR left the port of Mindelo, Cabo Verde, with fair weather conditions and a calm sea and headed towards the NIOZ dust buoy Michelle. After completion of the obligatory safety drill, the scientific program of the cruise started with sampling at the first test station in the early afternoon, which yielded unexpectedly rich planktonic foraminifera fauna and allowed for final adjustments of the multi-plankton-sampler (MPS) and our sampling procedures. The next morning we had our first full station with three MPS casts, which yielded over 3,000 planktonic foraminifera. The first successful photophysiological measurements of multiple foraminifera species were carried out. On Sunday August 13, we crossed the deepest parts of the Atlantic with over 6200 m water depth. Saharan dust covered the horizon, reducing the visibility to 9 km. We recovered the first samples from our continuous pumping system, which contained many benthic foraminifera species, most probably from the hull of the ship. On Monday August 14, we encountered the first rain and the yield of foraminifera from the daily station decreased.

On Tuesday August 15, we arrived at dust buoy Michelle in the early hours of the morning. The buoy was sighted in the early morning, hooked up for recovery via motor boat and was on deck by noon. We released a floating trap to collect particles and commenced the first full-day-sampling of the plankton in the afternoon. Almost the whole next day we sampled station after station with the MPS, the scientific crew worked in two shifts to manage the workload. After 26 hours, the sampling was concluded with a total of 41 net hauls carried out. We recovered the drifting trap, which had remained in sight of the radar for most of the full-day-sampling and released the sediment trap mooring M3 in the late afternoon. The top buoy was sighted at 18:20 and by 19:30 the first sediment trap was safely on deck. Following the recovery, we released the first ARGO float as last task at station M3 and started sailing towards M1. Along the track, we continued with our daily MPS stations, which yielded very few foraminifera. On Saturday August 19, we released the second ARGO float.

We reached the position of mooring M1 on Monday August 21, We released the mooring at 10:20 am but it took until 12:30 to sight it. The mooring recovery was accompanied by heavy rain and concluded by 15:00. Having M1 recovered, we headed in the direction of dust buoy Laura and deployed a test mooring of NIOZ halfway. This mooring will serve to determine the durability of a new and reusable type of mooring cable. We spent the night near the dust buoy waiting for sunrise to commence the recovery procedure. On Tuesday August 22 in the morning we began with the recovery of dust buoy Laura. The recovery was completed by 14:00 and after that we released a drifting trap. At 14:30 we commenced the second full-day-sampling. This second scheme was completed after ~25 hours and 46 profiles on Wednesday August 23. Next, we headed towards the deployment position of the new M1 mooring and started the deployment at 17:45; the bottom weight was dropped at 19:00. During the deployment, we witnessed a true tropical rainstorm with 38 mm rain in just 25 minutes and wind gusts of 9 Bf. On Thursday morning, we started the redeployment of dust buoy Laura at first daylight. The whole mooring was first deployed with a dummy buoy on top, which was later caught and replaced by the real dust buoy. This procedure prevented accidental submergence of the dust buoy during the deployment of the anchor weight. The whole operation took 7.5 hours and the buoy was safely in the water by 13:30. The deployed drifting trap was recovered during heavy rain and another ARGO float released at 15:15. This concluded the scientific program of the first leg and we headed towards Mindelo for the planned crew exchange on August 26.

We arrived in Mindelo as planned, entered the port at 9:00 and left again at around 11:00. In Mindelo three scientists left the METEOR, among them the chief scientist, and five scientists from MARUM and AWI embarked for the second leg. After leaving the port in direction of the Cape Blanc area, the ship's crew conducted a life boat exercise within the sheltered bay. On our way to dust buoy Carmen, a third ARGO float was released. The station was reached on August 27, at night. On the next morning, we started with the recovery of Carmen, which was completed quickly by collaborative work of the mooring teams from NIOZ and MARUM. Afterwards we recovered sediment trap mooring CB (deployment CB-28) and deployed two drifting traps. On August 29, the dust buoy Carmen as well as mooring CB (as deployment CB-29) were redeployed. We obtained several particle camera profiles before recovering the two drifting traps, which had collected material for approximately 24 hours. During the night, we reached the position of the eutrophic sediment trap mooring CBi, closer to the Mauritanian coast. We retrieved the mooring the following morning, deployed a drifting trap and obtained particle camera profiles for most of the day, while the CBi mooring was prepared for redeployment. On Thursday August 31, we obtained six camera profiles in around the future deployment position of CBi. In the afternoon we exchanged the deployed drifting trap in order to obtain two consecutive days of sampling. During all the mooring work conducted in the Cape Blanc area, the planktonic foraminifera team worked hard in the laboratories, processing the 200 samples of the first full-day-sampling scheme. Friday September 1 was the last full working day of M140. We redeployed CBi (as deployment CBi-16) without incident and obtained particle camera profiles at the mooring position until 17:00, when we ended station work and headed towards Las Palmas. On the September 3, we conducted our last MPS daily station. The cruise ended with the METEOR entering the port of Las Palmas at 10:00 on September 5, 2017. All aims of the cruise were met – the plankton sampling and particle characterization studies were carried out successfully and all moorings and buoys could be recovered and redeployed as planned.

5 Preliminary results

5.1 Physical oceanography

5.1.1 Plankton-sampler-mounted CTD unit

(Michael Siccha)

A CTD M90 (*Sea and Sun Technologies, Trappenkamp*, serial number CTD 979) was mounted on the multi-plankton-sampler (MPS) during all deployments. The instrument measured pressure, temperature, salinity, dissolved oxygen and chlorophyll-*a* at pressure difference intervals of 0.5 decibar. A pH sensor was also available, but a review of the obtained pH measurements indicated unrealistic values. A visual inspection revealed that the electrolyte inside the probe was leaking and pH measurements were thus discarded. All other sensors of the CTD unit (last calibrated on purchase in January 2015) worked without errors throughout the cruise. The unit was operating during each MPS deployment, resulting in the recovery of 40 CTD profiles of the upper water column at the 14 underway stations (Table 5.1). CTD profiles obtained at the position of the mooring stations M3 (GeoB22406-1), M1 (GeoB22410-1), CB (GeoB22414-9) and CBi (GeoB22416-3) are shown in figures 5.1 to 5.4. The profiles reveal a water column structure with a well-developed mixed layer of varying thickness and a distinct deep chlorophyll maximum. In addition to the underway measurements, the CTD unit was also operating during the full-day sampling schemes, resulting in additional 41 profiles in the region of Station M3 and 46 profiles in the region of Station M1. The raw and processed CTD data are published on PANGAEA.

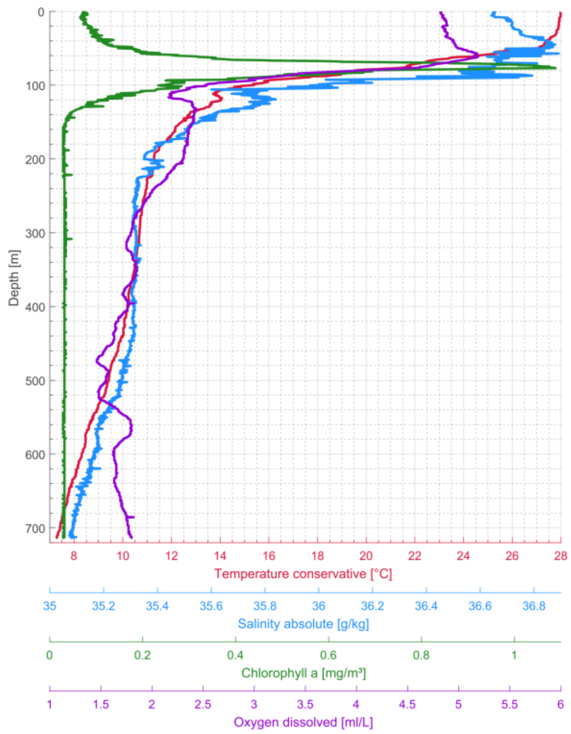

Figure 5.1: CTD profile of station GeoB22406-1.

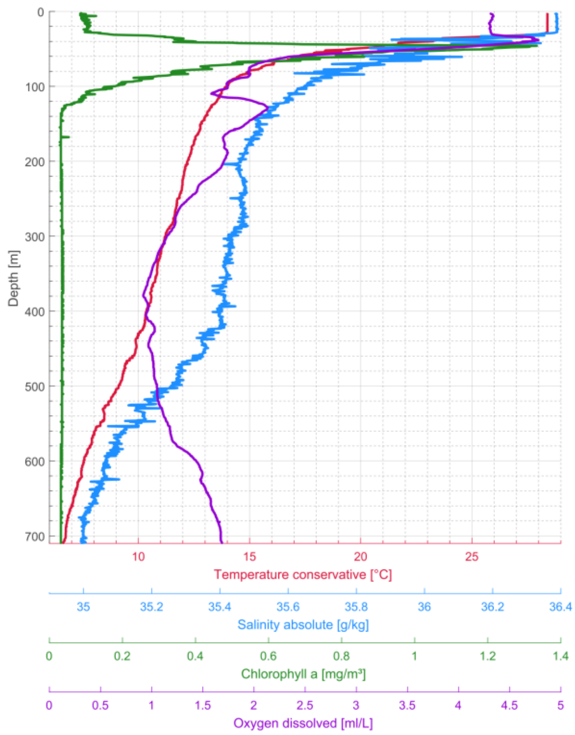

Figure 5.2: CTD profile of station GeoB22410-1

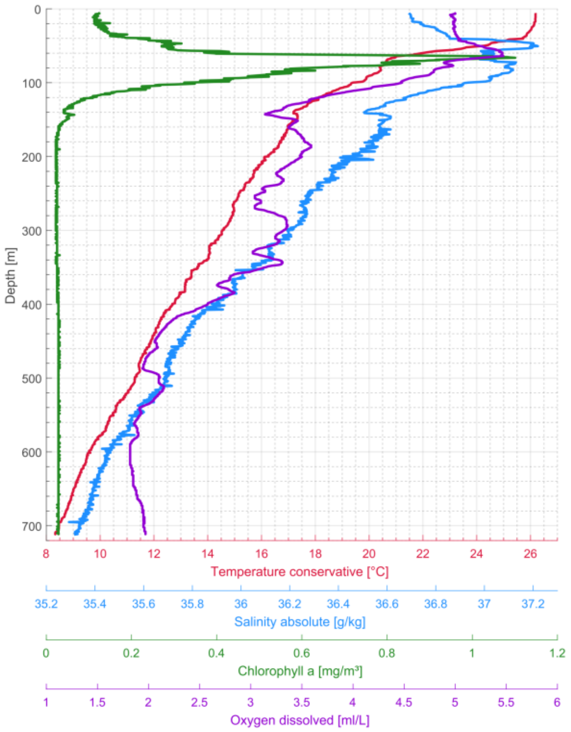

Figure 5.3: CTD profile of station GeoB22414-9.

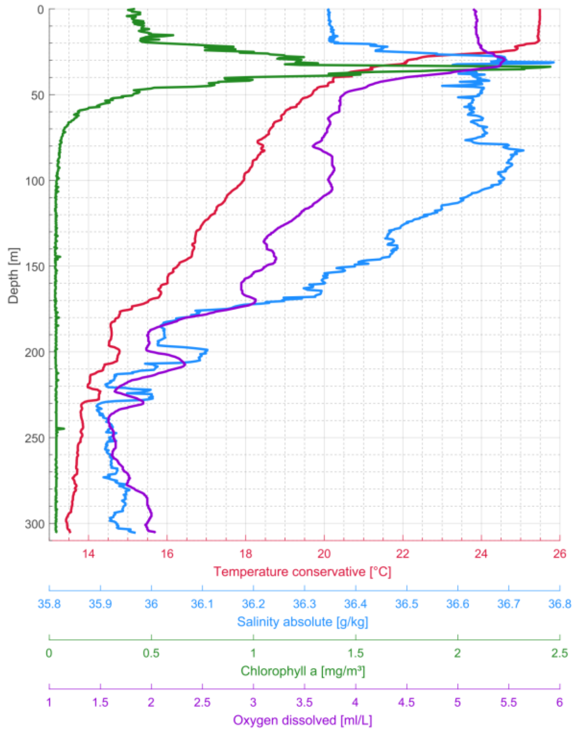

Figure 5.4: CTD profile of station GeoB22416-3.

5.1.2 Ship-board CTD unit with water sampling rosette

(Jeroen Groeneveld, Julie Meilland, Michael Siccha)

The onboard Seabird Electronics (SBE) 9 plus CTD (Conductivity-Temperature-Depth) (SN 979) mounted in a SBE water sampler rosette with 24 twelve L Niskin bottles was employed at stations GeoB22410-1 and GeoB22416-3. The CTD unit recorded temperature, salinity, chlorophyll *a* and dissolved oxygen concentration in the water column. The last calibration date of the instrument before the cruise was 24.10.2016. The main purpose of the instrument's deployment was to obtain water samples for water chemistry and phytoplankton community analysis to greater depths and with a finer vertical resolution and higher sample volume than what was possible with the MPS-mounted water sampler. In addition, the CTD provided in-situ seawater to fill the sediment trap sampling cups. The raw and processed CTD data are published on PANGAEA.

5.1.3 Ship's thermosalinograph

(Geert-Jan Brummer, Leonard Magerl)

The RV METEOR is equipped with two thermosalinograph (TS) units (*SeaBird Seacat SB 21E, SN 3313 and 3394*), measuring temperature and salinity in closed sea water throughflow (Inlet opening 1.5 m below sea surface). Measurements are averaged over 6 second intervals. The last calibration date of unit 3313 was the 12.8.2016, for unit 3394 12.4.2017. During M140 both units were operating throughout the duration of the cruise. Whilst exporting the salinity-data from DSHIP-database of the METEOR, we noticed a significant difference between the data from the TS1 and TS2. This appeared to be caused by fouling around the inlet. Comparing both datasets to the MPS-CTD profiles it appeared that TS1 produced biased measurements. Therefore only the data from TS2 will be used for further processing and investigated in relation to the obtained plankton pump samples. The data are available upon request.

5.2 Water column sampling and measurements

5.2.1 Water sampling

(Jeroen Groeneveld, Jacqueline Bertlich, Julie Meilland, Lukas Jonkers)

The MPS was equipped with a side-mounted water sampler with five 1.5 L Niskin bottles. The water sampler closed the bottles simultaneously with the opening of the MPS nets, i.e. at the base of each MPS sampling interval. Water samples were also obtained using the ship-board CTD rosette. In total, water samples were successfully collected from 66 casts at 33 stations. This includes all daily stations, ten stations at the M3 continuous sampling site, eight stations at the M1 continuous sampling site and the two CTD stations GeoB22410 and GeoB22416 (Table 5.1). For each of the daily stations as well as for M3 and M1, water was collected during two different casts to collect shallow and deep water. Water samples for pH, alkalinity and dissolved oxygen measurements were collected at every depth and analysed immediately on board (section 5.2.5.2). Sea water samples were also taken for measurements of nutrients, stable oxygen, hydrogen and carbon isotopes (section 5.2.5), as well as for coccolithophores (section 5.2.2.6.3). Samples for stable water isotopes were subsampled (2 mL) from the alkalinity sample bottles, at every depth and for every station listed in table 5.1.

Table 5.1: Stations and water depths of water samples taken during M140.
+ = $\delta^{13}C$ of dissolved inorganic carbon, * = O_2 (dissolved oxygen concentration), n = nutrients,
c = coccolitophoridae. A detailed overview of the sampling is available in the Appendix Water Chemistry

Station	Latitude	Longitude	Depth samples (m)
GeoB22401	16°38.87‘N	26°00.84‘W	50, 100, 150, 200, 250
GeoB22402	15°52.24‘N	28°44.71'W	$20^{*n,c}$, $40^{n,c}$, $60^{n,c}$, 80, 100*, 150, 200, 300*, 500, 700*
GeoB22403	14°47.432'N	32°31.642'W	$20^{*n,c}$, 40, $60^{n,c}$, $80^{n,c}$, 100*, 150, 200, 300*, 500, 700*
GeoB22404	13°43.550'N	36°13.398'W	$20^{*n,c}$, 40, $60^{n,c}$, $80^{n,c}$, 100*, 150, 200, 300*, 500, 700*
DVRS6536	12°24.66'N	38°38.08'W	140^{+}, 107^{+}, 75^{+}, 60^{+}, 31^{+}
DEAY9146	12°25.40'N	38°40.40'W	285^{+}, 221^{+}, 162^{+}, 93^{+}, 41^{+}
DPHE0358	12°28.848'N	38°37.131'W	97, 78, 53, 36, 17^{+}
BXDV7815	12°30.62'N	38°36.87'W	262, 193, 125, 83, 31
JMGX4246	12°33.05'N	38°39.44'W	251, 218, 162, 124, 67
KFVP3225	12°32.99'N	38°39.48'W	129, 112, 78, 56, 29
VWXU0012	12°31.32'N	38°31.20'W	124, 101, 71, 49, 22
BLJO8338	12°31.15'N	38°30.94'W	275, 209, 173, 119, 67
SVBT9363	12°23.11'N	38°34,68'W	225, 181, 141, 98, $35^{n,c}$
FUSH5410	12°23.30'N	38°36.35'W	131, 103, $84^{n,c}$, $50^{n,c}$, 34
GeoB22406	12°17.70'N	36°56.76'W	$20^{n,c}$, 40, $60^{n,c}$, $80^{n,c}$, 100, 150, 200, 300, 500, 700
GeoB22407	12°05.934'N	33°47.580'W	$20^{+n,c}$, 40^{*+}, 60^{+}, $80^{*+n,c}$, $100^{+n,c}$, 150^{+}, 300^{*+}, 500^{+}, 700^{*+}
GeoB22408	11°52.800'N	30°22.002'W	$20^{n,c}$, 40*, 60, $80^{*n,c}$, $100^{n,c}$, 150, 300*, 500, 700*
GeoB22409	11°41.28'N	26°39.73'W	$20^{+n,c}$, 40^{*+}, 60^{+}, $80^{*n,c}$, $100^{n,c}$, 150, 300*, 500, 700*

GeoB22410	11°26.20'N	22°49.05'W	10*$^{+n,c}$, 20*$^{+n,c}$, 30*$^{+n,c}$, 40*$^{+n,c}$, 50*$^{+n,c}$, 60*$^{+n,c}$, 80^{n,c}, 100*$^{+n,c}$, 160*$^{+n,c}$, 300*$^{+}$, 400*$^{+n,c}$, 700*$^{+}$, 1000*$^{+}$, 1250*$^{+}$
Fox	11°20.76'N	22°57.58'W	294, 232, 176, 107, 56
Goose	11°20.40'N	22°57.72'W	139, 110, 76, 44, 28
Shark	11°23.161'N	22°59.394'W	226^{+}, 189^{+}, 120^{+}, 89^{+}, 42^{+}
Octopus	11°23.933'N	22°59.649'W	131^{+}, 115^{+}, 81^{+}, 60^{+}, 31^{+}
Gull	11°27.32'N	22°55.47'W	241, 178, 137, 82, 40
Cat	11°26.96'N	22°54.26'W	130, 104, 81, 51, 21
Pig	11°24.77'N	22°54.02'W	221, 178, 145, 114, 58
Hedgehog	11°23.605'N	22°53.214'W	112, 94, 61, 41, 24
GeoB22412	14°06.08'N	23°44.68'W	20$^{+n,c}$, 40*$^{+}$, 60$^{+n,c}$, 80*$^{+n,c}$, 100^{+}, 150^{+}, 200*$^{+}$, 300*$^{+}$, 500^{+}, 700*$^{+}$
GeoB22413	19.51.99'N	22°59.07'W	20$^{+n,c}$, 40*$^{+n,c}$, 60*$^{+n,c}$, 80*$^{+}$, 100^{+}, 150^{+}, 200*$^{+}$, 300*$^{+}$, 500^{+}, 700*$^{+}$
GeoB22414	21°17.05'N	20°49.27'W	20$^{+n,c}$, 40*$^{+n,c}$, 60*$^{+n,c}$, 80*$^{+}$, 100^{+}, 150^{+}, 200*$^{+}$, 300*$^{+}$, 500^{+}, 700*$^{+}$
GeoB22416	20°50.70'N	18°47.96'W	10^{n,c}, 20$^{+n,c}$, 35*^{,c}, 40*$^{+n,c}$, 60*$^{+n,c}$, 80*$^{+n,c}$, 100*$^{+n,c}$, 150*$^{+}$, 240$^{+n,c}$, 330*$^{+n,c}$, 450^{+}, 500^{n,c}, 600*$^{+}$, 700^{+}, 900*^{n,c}, 1250$^{+n,c}$, 1600, 1800*$^{+}$
GeoB22417	20°52.19'N	18°56.33'W	20^{+}, 40*$^{+}$, 60^{+}, 80*, 100, 150, 200*, 300*, 500, 700*
GeoB22421	24°43.73'N	16°34.36'W	20$^{+n,c}$, 40*$^{+n,c}$, 60*$^{+n,c}$, 80*$^{+n,c}$, 100^{+}, 150^{+}, 200*$^{+}$, 300*$^{+}$, 500^{+}, 700*$^{+}$

5.2.2 Plankton sampling and sample processing

5.2.2.1 Underway plankton monitoring

(Geert-Jan Brummer and Leonard Magerl)

The „Plankton Pump" is a highly efficient way of collecting surface water microplankton in the >0.1 mm range along an entire cruise transect. It uses the ship's deck-wash or fire extinguishing system to continuously filter large volumes of surface water, without costing ship time, while sea surface parameters such as temperature and salinity are semi-continuously measured by the ship's system. It has been successfully used for three decades to sample skeletal microplankton, particularly the calcitic planktonic foraminifera. Continuous surface water plankton pumping (horizontal) is particularly attractive in combination with the water column sampling (vertical) and proved to be a robust sampling method during this cruise.

In the setup used during M140, surface water was continuously pumped from an inlet at 4 m depth in the bow of the METEOR, and passed through a hose into a plankton net (100 µm mesh size) that was suspended in a cube vessel on the deck. Every 12 hours, at around 9 am and 9 pm (ship-time), a sample was taken. Throughout the sampling, the pump was running with a flow of 2.5 m^3 per hour on average, so each plankton sample is the result of filtering about 30 m^3 of surface sea water, except during the two full-day sampling campaigns in the working areas M3 and M1, where the sampling interval was shortened to 3 h. To retrieve the sample, the hose was taken out of the net and used to rinse the net from the outside and concentrate the sample into the cod-end. The full cod-end was taken to the wet-lab and its content transferred onto a 90 µm sieve using pre-filtered sea water. The plankton sample was shortly rinsed with milli-Q to remove sea salt, and flushed into a small zip-lock plastic bag, labelled consecutively from PP1 to PP54 (Appendix table 11.1). Samples were frozen and stored at -20°C.

Generally, no problems were encountered. An exception occurred around station 44, where slimy plankton clogged the inside base of the net and could not be removed by rinsing with the hose. It was removed using a small spoon and added to the rest of the sample. The exact time of sampling was coupled to the ship's DSHIP-database to determine the exact GPS position at the start of sampling (in UTC) and extract temperature and salinity data from ships thermosalinograph 2. In the lab at NIOZ, all samples will be freeze-dried in their original sample bags, dry-weighed for biomass (total dry weight including the sample bag and post-weighing the empty sample bag), and dry-ashed to retrieve the skeletal matter (in an oxygen plasma using a low-temperature asher).

5.2.3.2 Underway Multi-Plankton-Sampler stations

(Philipp Munz, Michael Siccha, Adrian Baumeister, Manuel Weinkauf, Raphaël Morard, Paul Debray and Julie Meilland)

During transits to and from the mooring deployment stations, plankton tow casts were performed at 14 stations to collect planktonic foraminifera for population analyses, molecular genetic studies and geochemical proxy calibration (Table 5.2). A *Hydrobios MultiNet Midi* Multi Plankton Sampler (MPS) was used with an inlet size of 50 × 50 cm and five individual net bags with a mesh diameter of 100 µm. Slacking and hoisting was done with a rope speed of 0.5 m/s. After each net haul, the net bags were carefully rinsed from outside with sea water from the ship's pump and the cup's mesh cloth was washed and rinsed with filtered sea water. Opening and closing depths of each net bag were determined from the pressure readings from the pressure sensor of the device and controlled using a custom software script. It was programmed to activate the motor 2.5 m

Table 5.2: MPS underway station list

Date (UTC)	Ship station	GeoB-Station	Latitude	Longitude	Net casts (N)	Bulk samples (N)	Processed samples (N)	Env. gen. samples (N)	Isolated foraminifera
11/08/17	ME1400/984	22401	16° 38,88' N	026° 00,86' W	1	0	5	0	2799
12/08/17	ME1400/985	22402	15° 52,24' N	028° 44,71' W	3	1	9	5	3037
13/08/17	ME1400/986	22403	14° 47,44' N	032° 30,40' W	3	1	9	5	1058
14/08/17	ME1400/987	22404	13° 43,25' N	036° 12,91' W	3	1	9	5	1279
17/08/17	ME1400/1034	22406	12° 17,58' N	036° 56,55' W	3	1	9	5	605
18/08/17	ME1400/1035	22407	12° 05,75' N	033° 47,10' W	3	1	9	5	1153
19/08/17	ME1400/1036	22408	11° 52,85' N	030° 22,61' W	3	1	9	5	3001
20/08/17	ME1400/1038	22409	11° 41,26' N	026° 39,34' W	3	1	9	5	2101
21/08/17	ME1400/1042	22410	11° 26,41' N	022° 49,23' W	3	15	0	0	-
25/08/17	ME1400/1095	22412	14° 06,70' N	023° 44,43' W	3	1	9	5	3508
27/08/17	ME1400/1096	22413	19° 31,20' N	022° 35.44' W	3	10	0	5	-
28/08/17	ME1400/1104	22414	21° 16,89' N	020° 49,60' W	3	10	0	5	-
31/08/17	ME1400/1119	22417	20° 52,15' N	018° 56,26' W	3	10	0	5	-
03/09/17	ME1400/1134	22421	24° 43,73' N	016° 34,36' W	3	10	0	5	-

before reaching the next depth interval. The software simultaneously recorded parameter readings from the MPS, like opening/closing depth, activation time and sampled volume, as well as selected parameters from the DSHIP, such as position, wind speed, rope length and rope speed.
Except for the first station, which was used to test the equipment, each underway station consisted of three consecutive hauls with standard opening/closing depth intervals as follows: a deep cast starting at a depth of 700 m with the sampling intervals 700 – 500 – 300 – 200 – 100 – 0 m, a shallow cast starting at 100 m with the sampling intervals 100 – 80 – 60 – 40 – 20 – 0 m and an intermediate cast starting at 500 m with the sampling intervals 500 – 300 – 150 – 80 – 40 – 0 m. A CTD M90 (*Sea and Sun Technologies, Trappenkamp*, *Germany*, serial number CTD 979) was mounted on the MPS during all deployments and recorded water column properties simultaneously during each cast.
Before priority was moved to processing of the first full-day sampling, plankton samples from the deep and shallow casts of the underway MPS stations were processed directly on board using stereo dissecting microscopes. Individual planktonic foraminifera were extracted from the samples, transferred to cardboard micropaleontological sample slides, classified into living (with cytoplasm) and dead (empty test), scanned with a *Keyence* confocal digital microscope (see 5.2.2.4) and stored at -80 °C. The 100 – 0 m interval of the deep cast was frozen as a concentrated bulk sample for reference purposes. Samples that could not be processed on board were also stored as bulk samples. The samples of the intermediate MPS hauls were dedicated to the genetic analysis via Next-Generation-Sequencing (NGS). Samples from these casts were filtered using a vacuum filtration system and stored at -80 °C (see 5.2.2.6.1). All frozen samples were shipped on dry ice to the University of Bremen.

5.2.2.3 High resolution sampling

(Michael Siccha and Lukas Jonkers)

A full day high resolution sampling was conducted twice during the first leg of the cruise, first in the vicinity of the M3 mooring and second near the M1 mooring. To minimise temporal-spatial correlation between sampling locations and to obtain a distribution of inter-sample distances that is as continuous and flat as possible, samples were taken at randomly chosen locations within a predefined area. Similarly, the net intervals were designed in a semi-random way, allowing to detect changes in vertical abundances at a smaller scale than possible with a regular vertical resolution. All plankton tow casts consisted of five nets, with shallow and deep casts alternating between stations. Shallow casts had a random collection interval between 15 m and 35 m, deep casts between 30 m and 70 m. In order to sample the same water body the predetermined sampling positions were continuously updated during the progress of the full day sampling. A custom software script was employed to track progress of the sampling effort, update the sampling stations and communicate the sampling station positions to the bridge. The location of the sampling station position was continuously updated by a local background current velocity data obtained from the shipboard ADCP. Since the ADCP data cannot be read out online from the ship's system and needs to be processed before use, an update of the local background current velocity data could only be performed in intervals of about 6 hours. Preliminary analysis of the ADCP data shows median absolute current speeds of ~0.08 m/s, temporarily reaching 0.2432 m/s (95% percentile) near the M3 mooring.

The first continuous sampling was carried out centered around 38.5° W, 12.5° N and lasted from 15 August 2017 15:45 UTC until 16 August 2017 17:30 UTC. The initial, pre-drift corrected sampling area was a 400 km^2 square with 60 randomly distributed stations. An optimal itinerary was designed passing through 48 randomly chosen stations (the 12 remaining were optional in case extra was available). Within 26 hours we managed to sample 41 stations, averaging one cast every 38 minutes. All samples were frozen at -80 °C in bulk directly after the MPS deployment and during the remainder of the cruise samples were sequentially defrosted for isolation, counting and imaging of planktonic foraminifera. All samples were refrozen after picking and the residues were filtered for biomass determination.
The second full day sampling started on 22 August 2017 at 15:45 UTC and ended 25 August 2017 17:00 UTC near 23.0° W, 11.3° N. This time samples were taken in a 144 km^2 (pre-drift correction) square in order to investigate smaller scale spatial abundance variability and to obtain more samples. Similar to the first time, 48 stations were randomly chosen from a total of 60, but this time the sampling was started near the center of the square. We completed 46 casts, averaging one cast every 33 minutes. All samples were directly frozen at -80 °C and will be processed at MARUM.

5.2.2.4 Counting and morphometric analysis of foraminifera

(Adrian Baumeister, Manuel Weinkauf, Philipp Munz and Julie Meilland)

A key aim of the cruise was to study ecology of planktonic foraminifera in the region. In total 137 multinet casts were carried out at 104 stations, yielding 685 discrete samples. In 273 of these samples, foraminifera were isolated on board. This included all samples from the M3 area full day sampling area (205 samples from 41 stations) and 68 samples from the 14 daily stations. The daily stations samples were processed immediately onboard after sampling by multiple researchers (two persons per sample for samples shallower than 40 m and one person per sample for all other samples) while the M3 continuous sampling samples were frozen in sampling bags immediately after sampling and defrosted again for processing. The processing of a full station took between six hours and 1.5 days, depending on the overall density of plankton. Each scientist marked their slides with their initials in order to trace potential picking bias, and to ensure that the picking was exhaustive all samples were checked for completeness of processing by an experienced researcher. The isolated foraminifera were transferred individually to cardboard slides and sorted onto the slides pre-printed grid. The slides were then imaged with a digital microscope (Keyence VHX 5000), and afterwards stored at -80°C. The microscope setup consisted of the camera unit VHX-

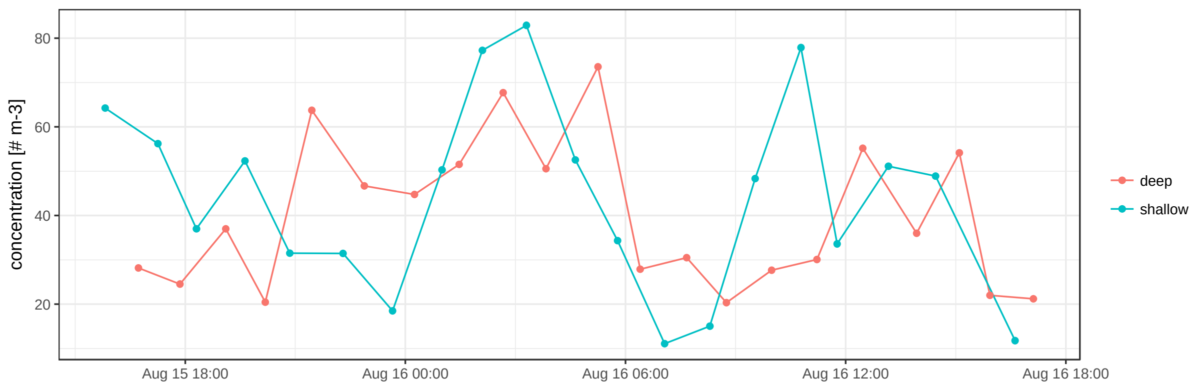

Figure 5.5: total planktonic foraminifera abundance in the top net during the full day sampling on 15 and 16 August, separated by shallow and deep casts. Note that the variability is of a higher frequency than a diurnal cycle.

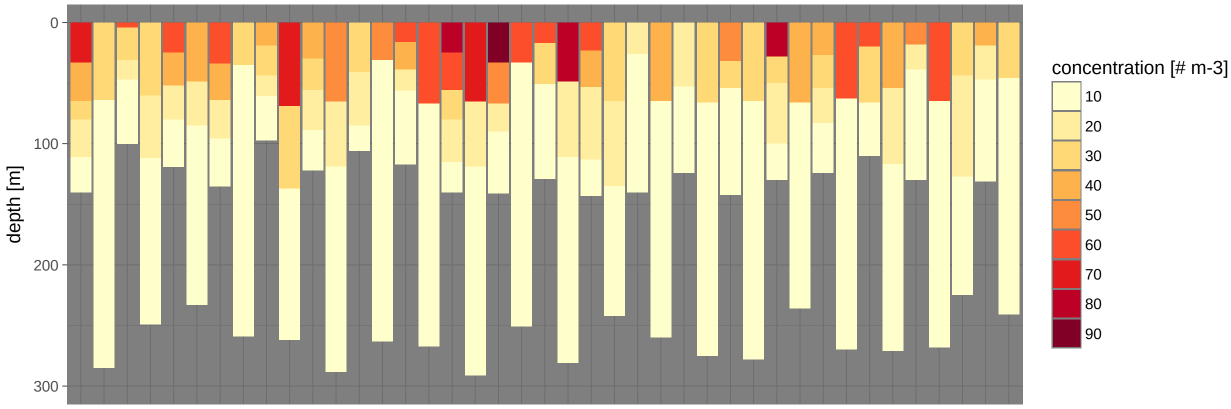

Figure 5.6: Total planktonic foraminifera abundance at each station during the full day sampling on 15 and 16 August. Profiles are ordered by time.

5100 and an ultra-small compact high-performance zoom lens (20x to 200x). To make the fully automated stitching of images possible the setup consisted as well of the VHX-S550 free-angle observation system with an XYZ motorized stage. The microscope, which has been rented for the cruise period from *Keyence*, is capable of stacking pictures taken at several focal planes to create a high resolution mosaic image with height information.

During extraction, the foraminifera were separated into those which contained cytoplasm (assumed to be alive) and those whose tests were already empty (dead) at the moment of collection. Separate scans for those two groups were performed. These images will deliver information about the distribution of ontogenetic stages within the dead and living fauna. Images were taken at 150x magnification. We tried to take pictures with a vertical stack resolution of 3 and 5 µm but such a high resolution drastically increased the time of scanning. Thus, regarding the large amount of scans to be produced, a resolution of 7 µm was considered the best compromise between resolution and scanning time. Every image was saved as a .jpg file. The height information is contained within the .jpg file and can be accessed by the Keyence software. To make further analysis possible, the height information for every pixel of the image was exported in separate .csv files.

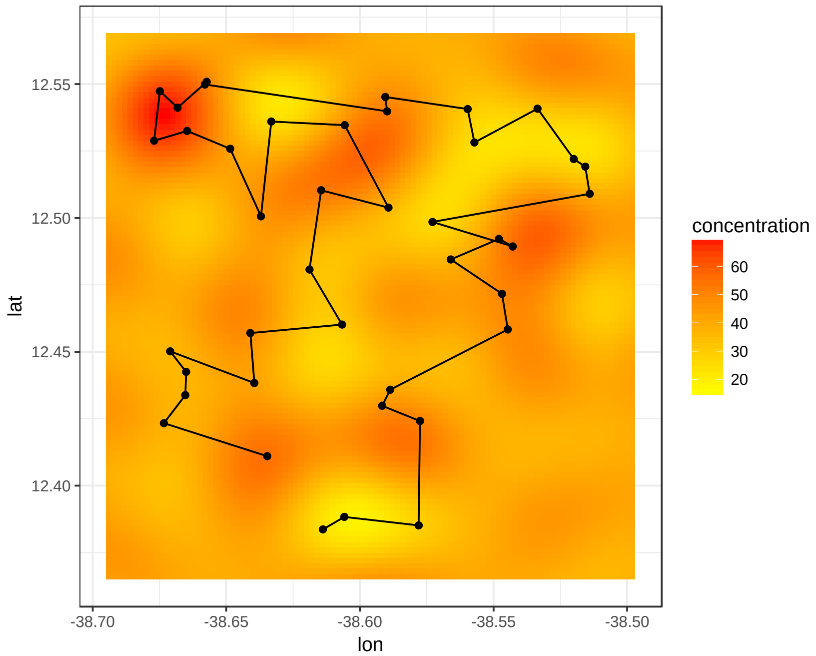

Figure 5.7: total planktonic foraminifera abundance (in # m^{-3}) in the topmost nets of the M3 area full day sampling show unprecedented variability at small spatial scales, suggesting patchiness in their distribution.

During the work with the Keyence, we encountered a few difficulties. Foremost, vibrations of the ship made it hard to automatically determine the correct focal planes/heights for the vertically resolved images. This technical problem could not be overcome onboard, but post-processing treatment is progressing and accurate size information from the onboard-acquired images will be extractable in the future. We further noted that the design of the slides is not optimal for

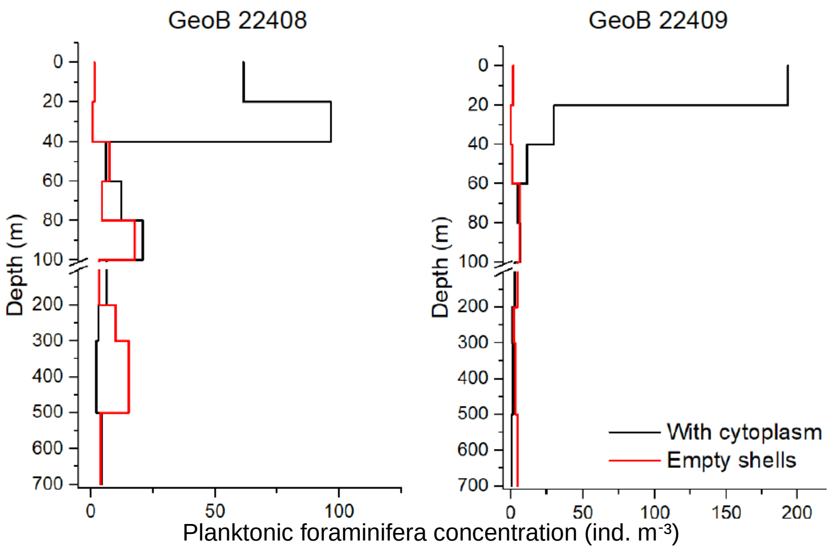

Figure 5.8: Vertical distribution of planktonic foraminifera abundance (ind. m^{-3}) at stations GeoB22408 and GeoB22409.

this application, because the white grid printed on the slides causes artifacts in the computed topography. We also noticed that the background colour of the slides is variable. The microslides are supposed to be plain black but under reflected light, at high magnifications, the color is patchy in different shades of grey. Finally, due to the use of sea water to manipulate and position the shells, the cardboard occasionally became uneven and salt crystals were built up. Both negatively impacted the ensuing particle analysis, but lead us to design new slides suitable for analysis with the *Keyence* microscope in collaboration with a private company (Kreativika).

In all of the 273 picked samples, empty and cytoplasm-bearing shells of planktonic foraminifera were counted on board, allowing preliminary analysis of the state and variability of the foraminiferal assemblage. In the M3 area, sampled during the full-day sampling scheme with 41 replicated 5-depth profiles, total planktonic foraminifera abundances varied between 1 and 83 individuals per m^3 with highest abundances virtually always at the surface (Fig. 5.5). Below 100 m, concentrations rarely reached more than 10 tests per m^3. There is clear variability in the near surface concentrations (11-83 tests m^{-3}; Fig. 5.5) that cannot be solely attributed to a dilution effect of the deep casts (Fig. 5.6). Broadly, two maxima are visible, a first centred around midnight on August 15 and a second around noon the next day. This indicates that planktonic foraminifera as a group do not show a diurnal cycle in their depth habitat.

The spatial abundance in the near surface layer (Fig. 5.7) shows patterns that are unlikely the result of temporal changes in the abundance. This is clearest in the north-western quadrant of the sampling area, but also in the north-east and the southern half, where stations at the beginning and end show elevated concentrations. The patterns indicates the presence of patchiness in the spatial distribution of planktonic foraminifera. These preliminary data clearly show the potential of the datasets from the two full day sampling efforts to shed light on the small-scale spatial and temporal population dynamics.

Data of the daily stations also show a strong variability among the stations. For instance, sampled with one day apart the stations GeoB 22408 and GeoB 22409 show exemplarily large differences in both planktonic foraminifera densities and distribution profile (Fig. 5.8).

5.2.2.5 Photophysiology of foraminifera symbionts

(Haruka Takagi and Christiane Schmidt)

To evaluate the photosynthetic performance of symbiotic algae within planktonic foraminifera, we conducted photophysiological assessments of individual foraminifera-algal consortia (holobionts). Among the 50 species of living planktonic foraminifera, about 1/4 are known to host photosynthesizing algae in their cells (Schiebel and Hemleben, 2017). The photosymbiotic algae (e.g., dinoflagellates, chrysophytes) are obtained from ambient environment and harboured as intracellular endosymbionts (Fig. 5.9). The photosynthetic performance of the symbiotic algae is an indicator of holobiont fitness and the photophysiology of the symbionts likely reflects an adaptation to light conditions. Among the ecological traits of planktonic foraminifera, the extent and rate of vertical migration during life is one of the biggest unanswered questions. Next to providing direct constraints on the existence of photosymbiosis, the evaluation of photophysiology of specimens collected at different depths has a potential to constrain the extent and prevalence of vertical migration or the existence of distinct depth stratification in symbiont-bearing species.
Specimens for photophysiology measurements were isolated from MPS and plankton pump samples. Individuals of different species were selected to either determine the presence of symbionts or to characterize their photophysiology at different depths. They were isolated using either brush or Pasteur pipette as soon as possible after sampling and used for on-board photophysiological measurements by fast repetition rate (FRR) fluorometer (DF-14BT, *Kimoto Electric Co., Ltd.*, Japan) and/or pulse amplitude modulation (PAM) fluorometer (IPAM, *WALZ GmbH*, Germany) (Fig. 5.9). Isolated specimens were transferred to multidish wells (Nunclon) filled with filtered sea water (0.45µm filtration), and maintained at room temperature until measurement.
In the FRR fluorometer, the specimens were put into a quartz glass cuvette and placed on the detection window of fluorometer. To obtain the fluorescence induction curve in photosystem II (PSII), this instrument generates a series of blue flashes (a wavelength of 470 nm with a 10 nm bandwidth, excitation light intensity of 30 mmol m^{-2} s^{-1}) at a repetition rate of 500 kHz in saturation phase, and 20 kHz in relaxation phase. We derived the PSII parameters from the fluorescence induction curve by using the numerical fitting procedure described by Kolber et al. (1998): these parameters included the minimum fluorescence (F_0), maximum fluorescence (F_m), variable fluorescence [F_v ($=F_m - F_0$)], potential photochemical efficiency (F_v/F_m), effective absorption cross-section of PSII (σ_{PSII}) and minimum turnover time (τ_{QA}). We also measured a light curve of holobionts (light level adaption, LLA) with sequential light intensity of 10, 20, 40, 60, 80, 100, 150, 200, 250, 300, 500, 1000, and 2000 µmol m^{-2} s^{-1}.

Figure 5.9: FRR fluorometer (left) and PAM fluorometer (middle), used during the cruise. Living *Globorotalia menardii* (right) from a sample particularly rich in this species (GeoB22414, 60-40 m).

Table 5.3: Summary of species and specimens of planktonic foraminifera analyzed for symbiont photophysiology (FRR and PAM fluorometers) and fixed for TEM and DNA analysis.

Species			LLA/RLC		Fixed for	
	FRRF	PAM	FRRF	PAM	DNA	TEM
Trilobatus sacculifer	17	4	10	2	4	3
Globigerinoides elongatus	11					
Globigerinodes ruber white	15	14	6	8	26	
Globigerinoides ruber pink	46	23	12	8	32	
Globigerinella siphonifera	31	14	3	2		10
Globigerinella calida	15	2			15	1
Orbulina universa	33	44	6	29	31	5
Globoturborotalita rubescens	19		4		15	
Globoturborotalita tenella	9		6		15	1
Hastigerina pelagica	23				21	1
Hastigerinella digitata	5				2	4
Beella digitata	2				1	
Globigerina bulloides	7	1			7	
Neogloboquadrina dutertrei	9	5	1		5	1
Pulleniatina obliquiloculata	2				2	
Globorotalia inflata	2					
Globorotalia menardii	185	188	34	46	135	117
Globorotalia scitula	78				16	2
Globorotalia crassaformis	18	10			5	11
Globorotalia hirsuta	2	1			1	1
Globigerinita glutinata	27		2		15	14
Globigerinita uvula	1					1
Candeina nitida	26				16	6
Tenuitella fleisheri	13				10	6

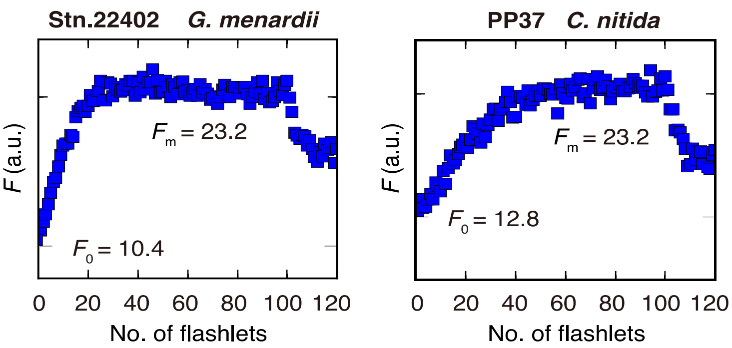

Fig. 5.10: Examples of fluorescence induction curves obtained by FRRF measurement of photosymbiotic planktonic foraminifera (left: *G. menardii* from Stn. 22402, 80–60m depth / right: *C. nitida* from plankton pump, 4m depth).

The PAM fluorometer (*WALZ GmbH*, Germany) was equipped with MAXI-Head, 1/2" and CCD camera (K7) and zoom objective (F1.0/f = 8–48 mm). It was used to assess the maximum quantum yield (F_v:F_m) and conduct rapid light curves (RLC). The light environment around planktonic foraminifera is highly fluctuating, hence the RLC provides reliable assessment of photosynthetic activity by integrating the symbiont ability to tolerate fluctuating light conditions (Ralph and Gademann 2005). Individual foraminifera specimens were cleaned from adhering algae and put into a petri dish containing filtered sea water (0.45 um). Only specimens >250 µm could be measured using the PAM setup. Specimens were measured for the F_v:F_m after 10-15 min dark adaptation. Areas of Interest were manually placed in form of circles covering the surface area of the individual foraminifera using the zoom function in the software Imaging Win 2.46i (*WALZ GmbH*, Germany. For the conduction of the RLCs foraminifera were exposed to 17 increasing irradiance steps of 10 s each which were as follows: 2, 9, 21, 32, 50, 70, 97, 127, 163, 200, 240, 290, 335, 390, 449, 506, 589 µmol photons m^{-2} s^{-1}. The irradiance emitted by the LEDs of the IPAM instrument was calibrated using a hand-held PAR Light Meter (*Apogee*, USA). After exposure to each actinic light step the effective quantum efficiency $\Delta F/F_m$' was measured. For every irradiance level, the relative electron transport rate (rETR = $\Delta F/F_m$' × PAR) was calculated.

After the photosynthetic measurements, some of the specimens were isolated for DNA analysis of symbiotic algae, and transmission electron microscopy (TEM) observation. Specimens for DNA analysis were transferred into micropaleontological slides, photographed individually, air dried and then stored at –80°C. Specimens for TEM observation were transferred into 200 µL micro-tubes containing 100 µL fixation buffer for electron microscopy (Glutaraldehyde-Formaldehyde-

Cacodylate buffer for electron microscopy, *Morphisto GmbH*). In total, 596 specimens of 23 species were investigated by FRR fluorometry (total number of measurement 2035), 308 specimens of 11 species by PAM fluorometry, 374 specimens of 20 species were collected for DNA analysis and 184 specimens of 16 species were fixed for TEM (Table 5.3).

5.2.2.6 Plankton filtration

5.2.2.6.1 Sampling for plankton environmental genomics

(Raphaël Morard and Paul Debray)

The filtration system used to concentrate the content of plankton net samples consisted of 3 funnels of 500 ml mounted in series on a filtration ramp and connected to a pump and a vacuum bottle (Fig. 5.11 1). Before each collection, all parts of the filtration system in contact with the sample were washed using 96% ethanol and MilliQ water to eliminate potential contaminants. After cleaning, a cellulose filtration membrane with 47 mm diameter and 12 µm pore size was placed on the gasket using sterile tweezers and the funnel was screwed on top. At every daily station, one entire MPS cast was dedicated to sampling for metagenomics analysis. The sampling was done at the intervals of 500-300, 300-150, 150-80, 80-40 and 40-0 meters. After the MPS recovery the contents of the cod-ends were transferred into a 1-liter beaker through a 2-mm sieve to remove large zooplankton particles that would clog the filter (Fig. 5.11 2-3). The particle above 2 mm were

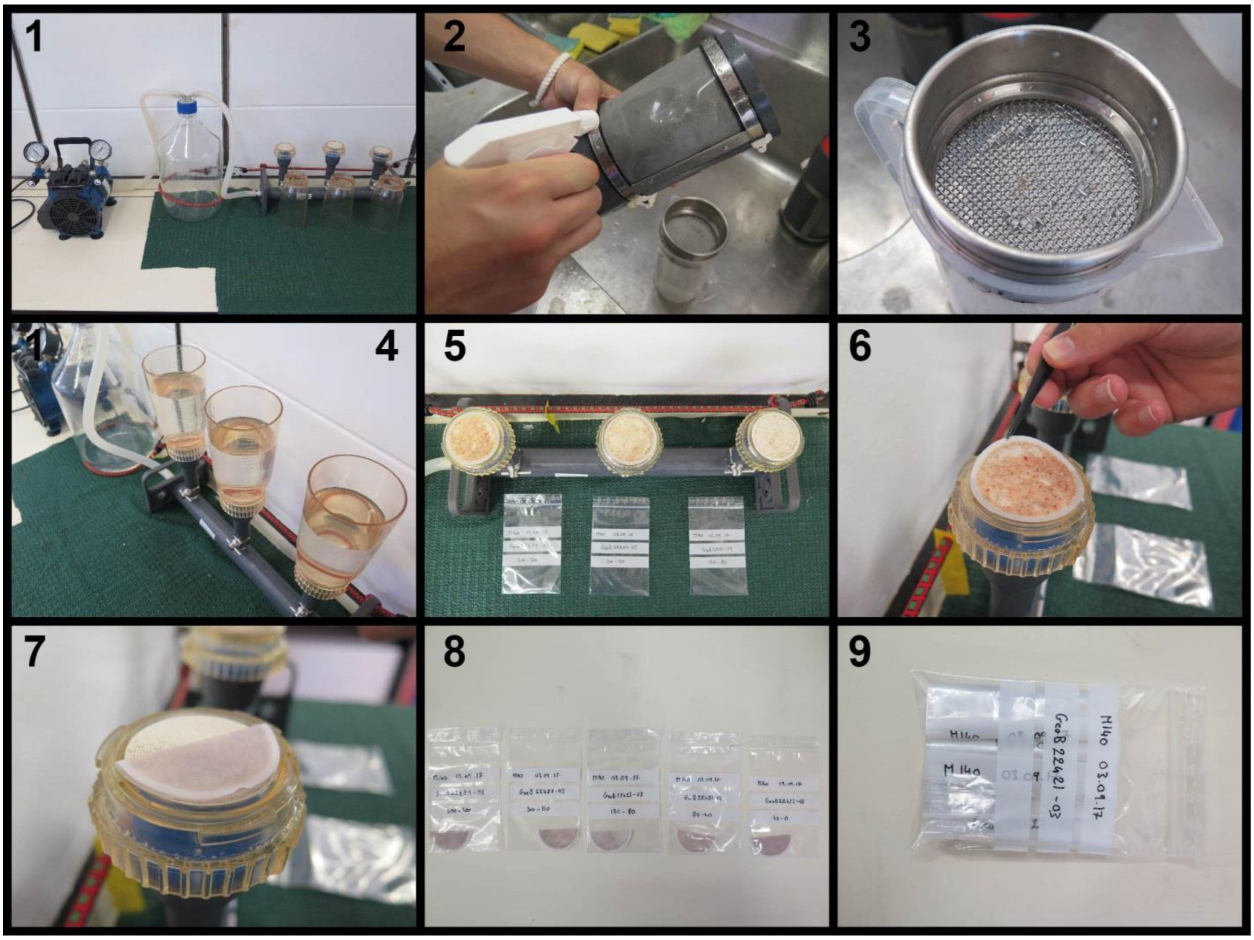

Figure 5.11: Workflow of the filtration for metagenomics during M140. (1) Filtration setup (2) rinsing of the cod-end mesh (3) large plankton particles retained in the sieve (4) samples ready for filtration (5) plankton concentrated on the filters (6-7) folding of the filter (8) individual sampling bags (9) final collection per station.

discarded. The mesh of the cod-ends was rinsed carefully using a squeezing spray bottle until all the particles were removed and transferred into the beaker. The contents of each beaker were carefully poured into a filtration funnel. The beakers were rinsed thrice with filtered sea water to ensure that no planktonic particles remained. After the three first samples were ready (Fig. 5.11 4), the pump was switched on and the samples were filtered. After all sea water was filtered, the inner part of the funnel was rinsed with filtered sea water (12 µm). Afterwards the pump was switched off and the funnels unscrewed (Fig. 5.11 5). The filters where folded and placed into labelled sampling bags (Fig. 5.11 6-8). After the first three samples were processed, the filtration system was cleaned and the remaining two samples from the haul were processed following the same procedure. In the case of rich samples, usually from the uppermost layer of the water column, the entire sample could not be processed with a single filter because of material clogging the membrane. In such case, the pump was switched on and then the sample was poured progressively on the filter until it started to be clogged. The pouring was then interrupted and the filter exchanged with a new one. The operation was repeated until the whole sample was processed. For 50 samples only a single filter was needed and for 15 samples 2 to 8 filters were necessary. When the last sample was filtered, all the labelled bags were gathered and frozen at -80°C (Fig. 5.11 9). The entire process was always completed within an hour from the recovery of the sample. A total of 65 samples from 13 stations have been filtered during the cruise.

5.2.2.6.2 Determination of plankton biomass

(Marina Rillo, Raphaël Morard and Paul Debray)

In order to understand the spatial distribution of planktonic foraminifera species, it is important to determine all potential controlling factors. One of these is the total particle load of the water column, a quantity distinct from productivity, but likely highly correlated to the biomass of potential foraminiferal prey. To determine the particle load of the water column during the cruise, once all planktonic foraminifera were removed and mounted on slides, the residue of each of the processed plankton samples was collected and filtered to estimate the plankton biomass by measuring dry weight of the residue. To this end, the same filtration system as described in section 5.2.2.6.1 was used. Before each filtration, the parts of the filtration system that are usually in contact with the samples were washed with freshwater. Next, a cellulose filter of 47mm diameter and 12 µm pore size was placed on each gasket and the funnel was screwed on top. The sample residue remaining after the foraminifera were picked was transferred into one funnel and the beaker containing the sample was rinsed three times with filtered sea water to ensure than no plankton particles remained in the beaker. After the three first samples were ready for filtration (Fig. 5.11 4), the pump was switched on and the samples were passed through the cellulose filter. After all the sea water was

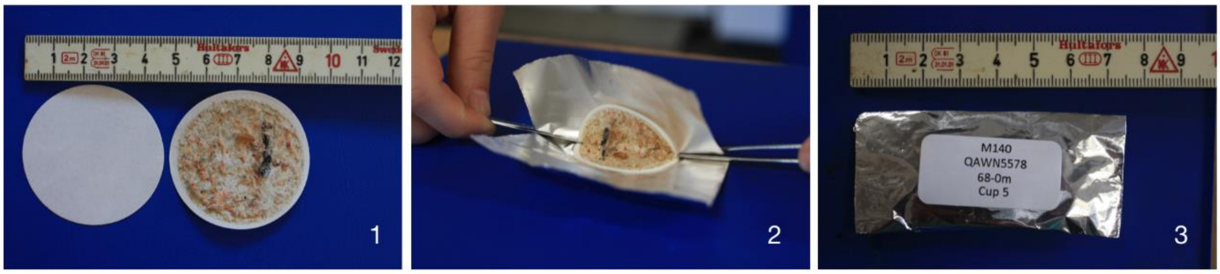

Figure 5.12: Filtration for plankton biomass during M140: (1) Filter before and after filtration (2) Folding of the filter with aluminium foil (3) final result with label.

filtered, the inner part of the funnel was rinsed with filtered sea water (12 µm) to ensure that no particles remained attached to the filter funnel. After the pump was switched off and the funnels unscrewed (Fig. 5.11 5), each filter was transferred to a labelled Petri dish and dried at 60 °C. Dried filters were carefully folded, wrapped in aluminium foil (Fig. 5.12) to preserve the structure of the specimens (e.g. copepod exoskeleton), labelled and frozen at -20 °C.
Initially we attempted to weigh the filters on board before and after the filtration. We set up a two-scale system in which one scale measures the weight of the object (filter) and the other scale uses a known weight (1 g) to compensate for the acceleration by movement of the ship. Unfortunately we ran into some difficulties with the measurement synchronisation between the balances and had to abandon this attempt. Consequently, the filters will be weighted at MARUM. It is important to notice that the samples were filtered fully, which means that the filters might contain inorganic matter such as dust and particles detached from the vessel during water sampling. In fact, some samples contained oxidised metal particles likely coming from the ship's cable von which the MPS was deployed. In future cruises, we would recommend removing these metal particles from the sea water samples.

5.2.2.6.3 Phytoplankton community sampling

(Julie Meilland)

Water samples were filtered along the cruise track, in order to analyze the diversity and standing stock of coccolithophores in the water column. Morphometric analyses of the cells and the liths for selected species will be performed using automatic microscope routines developed at CEREGE. This dataset will be included in the large plankton filter dataset that contains samples collected over the last decade, and is used to assess the link between carbonate system chemistry and the calcification of coccolithophores. During M140, a total of 57 samples were taken from 15 stations (Appendix table 11.2). For 13 stations, samples were collected from the Multi-Plankton Sampler bottles. At each station 3 samples were taken: 1) in subsurface (20 m depth); 2) in the Deep Chlorophyll Maximum (DCM), ranging from about 80 to 35 m depth; 3) below the DCM. For each sample 450 to 1620 ml of water was collected, depending on the amount of water left in the Niskin bottles. For the 2 other stations, samples were collected down to 1250 m depth and with a higher resolution using the shipboard CTD-rosette. Each sample had a volume of 3 L in order to optimize chances to get enough material. After the sampling, the collected water was immediately filtered over a 0.8 µm membrane using the filtration system described in section 5.2.2.6.1. The filters were then stored in individual bags and dried at 60°C.

5.2.3 Drifting traps

(Morten Iversen, Jan-Berend Stuut and Christian Konrad)

Export fluxes in the upper 400 m of the water column were determined by free-drifting sediment traps (Fig. 5.13). Six deployments were carried out during the cruise (Table 5.4). Each deployment used four cylindrical traps fixed at 100, 200, and 400 m. At each depth three of the four trap cylinders collected bulk fluxes while the fourth cylindrical trap was equipped with a viscous gel that preserved the sinking organic particles in their original shape. All, but one, deployments were successful, only at station M140-M3, the gel trap at 200 m failed. One of bulk fluxes samples of each deployment was preserved with $HgCl_2$ and will be used to determine mass fluxes of carbon, nitrogen, biogenic opal, calcium carbonate, and lithogenic material. The different particle types collected in the gel were photographed using a digital camera (Keyence) and will be used to determine particle size distribution of the flux and to identify transformation processes between the different trap depths. After poisoning or imaging all samples were frozen at -20° C, They were transported in frozen state to MARUM, where they are stored now.

Vertical export of organic matter is typically dominated by marine snow aggregates and zooplankton faecal pellets (Fig. 5.14). These particles are degraded by microbes and fed upon by zooplankton while they sink. However, it is still unclear how these degradation processes influence the efficiency of the biological pump at different seasons in different regions. By investigating the composition of vertical fluxes at different depths in the upper water column, we hope to observe and understand the processes responsible for the transformation and degradation of sinking particles. A first glimpse into the material collected in the gel traps revealed that faecal pellets especially from copepods were common in the exported material but that marine snow aggregates seemed to make up a large part of the exported material as well (Fig. 5.14).

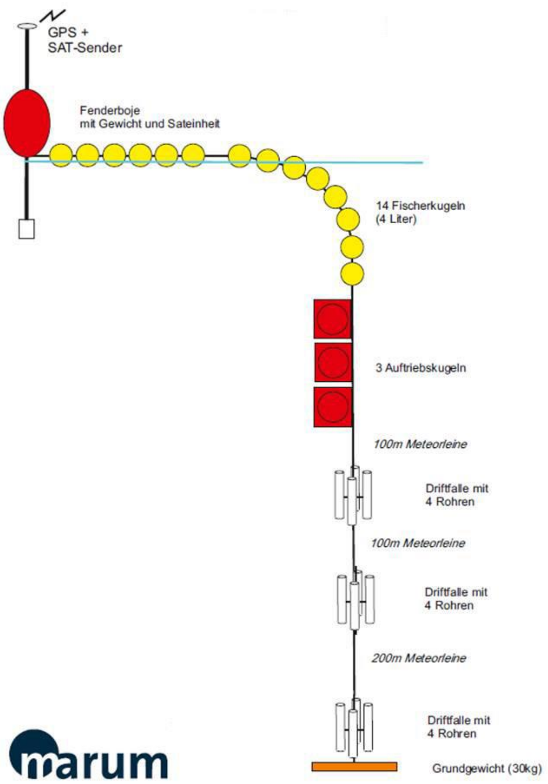

Figure 5.13: Scheme of the deployed drifting traps.

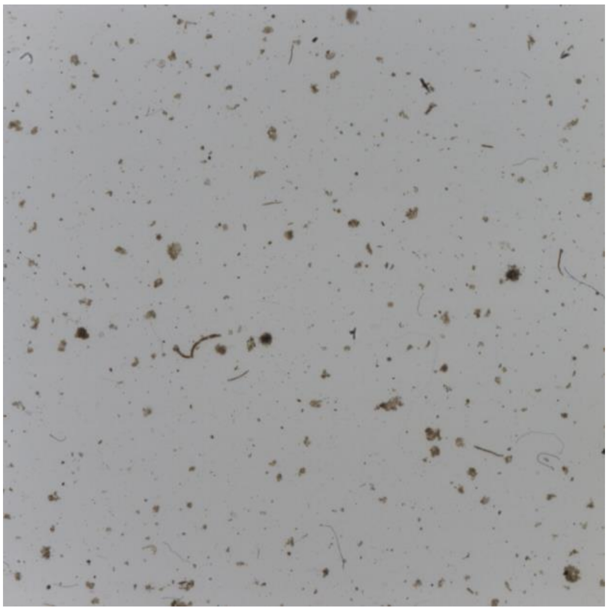

Figure 5.14: Example of material collected at 100 m during the DF-19 drifting trap deployment. There were several marine snow aggregates and some copepod faecal pellets.

Table 5.4: Drifting Trap deployments during M140. Each deployment used four cylindrical traps fixed at 100, 200, and 400 m.

Ship's station	Station No.	Date [UTC]	Time [UTC]	Action	Depth [m]	Latitude	Longitude
	M140-M3	15/08/17	14:35	Dep	4694	12°23.88'N	38°38.24'W
	M140-M3	16/08/17	17:50	Rec	4645	12°22.24'N	38°35.66'W
	M140-M1	22/08/17	14:15	Dep	5113	11°23.39'N	22°57.22'W
	M140-M1	24/08/17	15:30	Rec	5098	11°27.85'N	22°51.53'W
	M140-CB	28/08/17	16:15	Dep	4160	21°14.99'N	20°50.71'W
	GeoB22414-7	28/08/17	18:06	DF18 Dep	4173	21°16.124'N	20°49.986'W
	M140-CB	28/08/17	18:00	Rec	4173	21°15.95'N	20°50.14'W
	GeoB22415-3	29/08/17	19:54	DF18 Rec	4174	21°17.340'N	20°49.470'W
	M140-CBi	30/08/17	14:50	Dep	2800	20°50.66'N	18°47.59'W
	M140-CBi	31/08/17	17:15	Rec	2820	20°52.77'N	18°47.01'W
	GeoB22419-1	31/08/17	17:55	DF19 Dep	2828	20°53.189'N	18°46.990'W
	GeoB22419-6	01/09/17	18:05	DF19 Rec	2720	20°53.544'N	18°43.226'W

5.2.4 Particle camera surveys

(Morten Iversen and Christian Konrad)

The DriftCam (Fig. 5.15) was deployed during the cruise to capture the vertical distribution of particle abundances and size-distribution in the upper 500 m of the water at high temporal resolution during day and night. The DriftCam was deployed either as a profiling system or in stationary mode (DriftCam at 100 m depth during a longer period). When the DriftCam was deployed as a profiling system it was capturing an image every three seconds to a depth of 500 m. The image frequency was every 10 second in the stationary mode. We made four test deployments to optimize the settings and the flash, aperture, and exposure. In total we deployed the DriftCam 24 times (20 profiles to 500m and 4 stationary deployments to 100m (Appendix table 11.3).

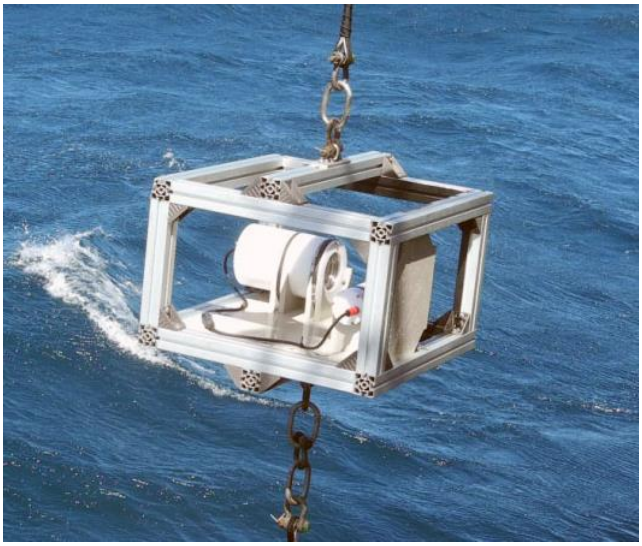

Figure 5.15: Image of the DriftCam during deployment at M140. The camera housing can be seen to the left in the frame while the flash housing is on the right side.

The DriftCam consists of a Canon EOS 600D DSLR (18 Megapixel) with an EF 50.2 macro-lens connected to a Canon Speedlight 430 EX II flash. Camera and flash were installed each in a POM pressure housing with a depth rating of 500 m. The camera could be programmed by using a Delamax LCD Timer, which allows time-lapse exposures at given intervals. The pressure housings for the camera and the flash were mounted inside an aluminium frame; total weight is ~100 kg. The flash was mounted perpendicular to the optical axis of the camera at a distance of ~ 30 cm. During all deployments, the DriftCam delivered continuous vertical profiles of particle abundance and size-distribution. The first inspection of the images revealed several large aggregates in the

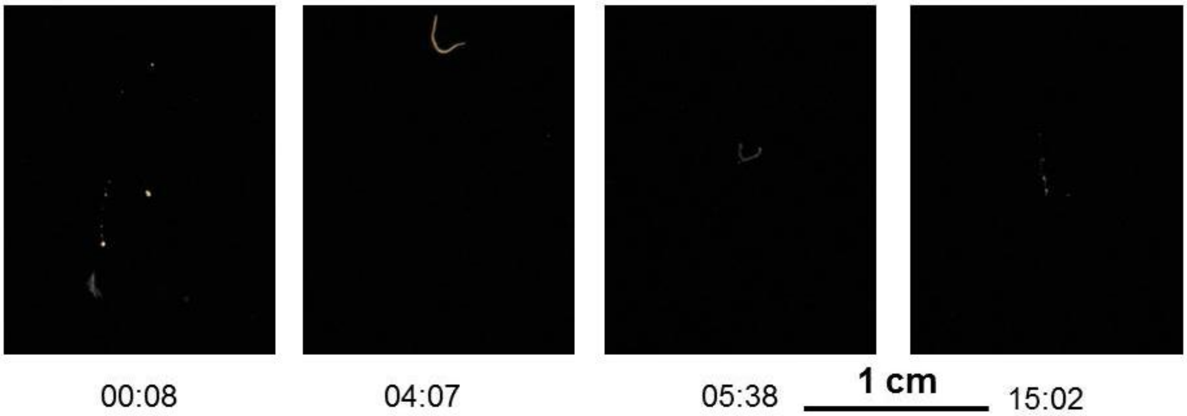

Figure 5.16: Examples of images obtained by the DriftCam (stationary deployments 1-4, see table A3).

surface water, while the deeper water seemed to mainly contain small and compact aggregates (Fig. 5.16). For the long stationary deployments, we expected to see a shift from marine snow towards faecal pellets during night when the zooplankton migrated to the surface water to feed. Some indications support this hypothesis, but we still need to await the final data analyses.

5.2.5 Water chemistry

The collection of water samples for chemical analyses was performed using the water collected from the Niskin bottles on the multi-plankton sampler (MPS) at each of the underway MPS stations (Table 5.1), on selected stations during the two full day sampling schemes, and during both deployments of the on-board CTD (see 5.2.1). Water samples were collected to determine alkalinity, pH (to be compared to the pH-sensor of the MPS-CTD), and dissolved oxygen (to be compared with the oxygen-sensor of the MPS-CTD and the on-board CTD), and to collect samples for $\delta 1^{8}Osw$, $\delta^{13}C_{DIC}$, nutrients, and nannoplankton content (see 5.2.2.6.3). Additionally, each day two surface water samples were taken from the onboard sea water supply for $\delta^{18}O$ and δD. The resulting water-chemistry profiles will allow us to better constrain environmental factors affecting the occurrence of planktonic foraminifera in the water column and to characterize the incorporation of trace metal and isotopes into their tests. Combining CTD profiles with alkalinity and pH allows to calculate the different parameters of the carbonate system in the water column and thus to study the impact of carbonate chemistry on foraminifera shell composition. The effects of dissolution (low saturation state) and the carbonate ion effect (increasingly important for the incorporation of Mg in deeper living species) are relatively well known for benthic foraminifera (Regenberg et al., 2006; Raitzsch et al., 2008), but the effect on planktonic foraminifera is largely unknown.

5.2.5.1 Alkalinity and pH

(Jeroen Groeneveld and Jacqueline Bertlich)

Sea water samples from MPS Niskin bottles were taken at water depths corresponding to the water depths at which the respective plankton nets were opened (Table 5.1). For each cast up to ten samples were collected into 100 mL bottles, which were rinsed with MilliQ and 2-3 times with sea water from their respective depths. To obtain full vertical profiles during the full-day sampling, water samples were always taken from two subsequent stations, representing successive shallow and deep casts. During the sampling in the M3 region ten stations were processed for water chemistry and during the sampling in the M1 region eight stations were processed. Samples from the two on-board CTD casts were taken throughout the water column at 14 and 18 depth levels. Alkalinity determination should ideally be performed as soon as possible after collection. Starting with the deepest (i.e. furthest away from atmospheric equilibrium) sample, the pH was measured (WTW pH/Oxi 340i), after which a manual titration was performed using 10 mmol HCl. At a pH between 3.5 to 4 the final pH was measured. A total of 252 samples (33 stations, 757 titrations) were processed for determining alkalinity and pH (Appendix table 11.4). Each sample was processed three times to calculate errors of determination, which were 0.018 kg^{-1} (0.72%) for alkalinity and 0.013 (0.16%) for pH.

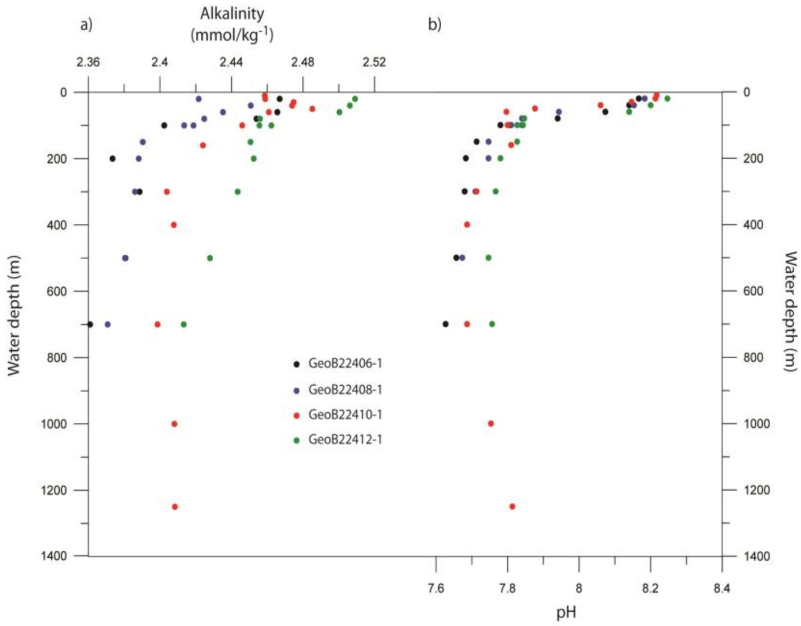

Figure 5.17: Characteristic alkalinity (a) and pH (b) profiles of the sampling areas off northwest Africa measured during M140.

Vertical profiles of pH mostly followed a strong decrease from the surface (8.2 to 8.0) down to about 200 m, with a minimum around 500 m (7.6; possibly related to AAIW) after which changes are small but generally slightly increasing again with increasing water depth (7.6-7.8) (Fig. 5.17b). The observed alkalinity profiles were also consistent throughout the sampled area (Fig. 5.17a). In general, highest alkalinity occurred in the mixed layer (2.46-2.54 mmol kg^{-1}) with occasionally slightly lower (e.g. GeoB22410-1; 0.02-0.04 mmol kg^{-1}) values in the top 20-40 m coinciding with lower salinity in the surface layer. The lowest values (2.36-2.41 mmol kg^{-1}) were observed below 200 m. However, at several stations which were sampled during early evening a different vertical profile was observed, with alkalinity remaining stable down to 100-150 m (e.g. station SVBT9363) or reaching higher values than at other stations (e.g. station DPHE0358, 2.6-2.68 mmol kg^{-1}). This may be related to respiration changes during the daily migration of zooplankton towards the surface at night.

5.2.5.2 Dissolved oxygen concentrations

(Jeroen Groeneveld and Jacqueline Bertlich)

During daily sampling stations and the two shipboard-CTD casts water samples were taken to determine the dissolved oxygen concentrations. The aim was to calibrate the oxygen sensor on the MSP-CTD probe. The shipboard-CTD also contained an oxygen-sensor for additional comparison. Dissolved oxygen concentrations were determined using the Winkler method (Hansen, 1999). Directly after sampling the water from the Niskin bottles into glass bottles, which were rinsed until two volumes were washed through and no air bubbles were left, the dissolved oxygen in the seawater was fixed by adding $MnCl_2$ and a mixture of KI and KOH. Vigorous shaking ensured that all oxygen was fixed. After a resting period of about half an hour the precipitate was dissolved by adding sulphuric acid and subsequently starch as a colour-marker for the I_3 in the solution. Titration with sodium thiosulphate (0.2 mol/L) removed the I_3 from the solution, as marked by a return to a clear solution. The amount of sodium thiosulphate added to the solution was then converted into the original dissolved oxygen concentration. A total of 80 titrations at 14 different stations were performed (Appendix table 11.5). The resulting oxygen concentration profiles showed good agreement with the profiles of the oxygen sensor of the shipboard CTD (Fig. 5.18) and confirmed the malfunction of the oxygen sensor of the MPS-mounted CTD probe. The obtained vertical profiles confirmed the presence of a well-developed oxygen minimum zone between 200-800 m (Fig. 5.18).

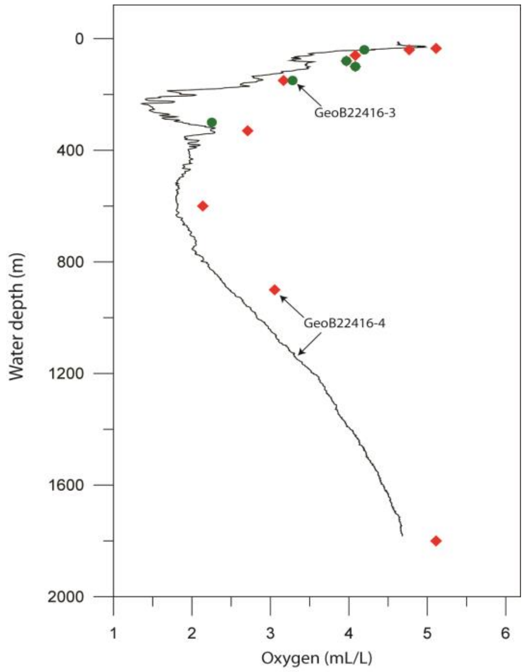

Figure 5.18: Comparison of dissolved oxygen concentrations determined by Winkler-titration and measured by shipboard- and MPS-CTDs for GeoB22416-3 (MPS) and GeoB22416-4 (shipboard CTD).

5.2.5.3 Stable oxygen and deuterium isotopes

(Jeroen Groeneveld and Jacqueline Bertlich)

At each station where water was collected for alkalinity titration, an aliquot was separated and stored in 2 mL glass vials for analysis of stable oxygen isotopes. A total of 249 samples were taken from 33 different stations (Table 5.1). In addition, samples for the analysis of stable oxygen and hydrogen isotopes in surface water were taken daily. Samples were roughly taken at the same time (early evening UTC time) from the seawater tap in the laboratory (inlet at approx. 5 m water depth). Samples were stored in 2 mL glass vials, which were rinsed three times with seawater and stored in a fridge. A total of 52 samples for oxygen and hydrogen isotopes were taken from 26 locations (Appendix table 11.A6).

5.2.5.4 Stable carbon isotopes

(Lukas Jonkers)

Water samples for measurement of $\delta^{13}C$ of dissolved inorganic carbon (DI$\delta^{13}C$) were taken with a twofold aim. Firstly, to gain understanding into carbon cycling in the ocean within the framework of a large-scale monitoring project by Gema Martínez-Méndez (MARUM) and secondly to aid the interpretation of $\delta^{13}C$ in planktonic foraminifera calcite in order to better constrain its use as a proxy for past surface ocean processes. A total of 108 samples were taken (Table 5.1). At the underway stations, samples were taken at regular depth intervals (700, 500, 300, 200, 150, 100, 80, 60, 50, 20 m) with one duplicate at 100 m. During the full day plankton sampling, DI$\delta^{13}C$ samples were taken at irregular depth intervals down to approximately 300 m. Two longer profiles down to 1200 m were obtained using the shipboard CTD rosette. For each sample, 30 mL of seawater was taken ensuring that no bubbles were present in the bottle. Samples were poisoned with

30 µL saturated $HgCl_2$ solution, sealed with parafilm and stored at 5 °C. All bottles were bubble free after poisoning, but showed presence of bubbles after cooling. This is likely because a small amount of air that was present below the seal in the bottle cap was sucked into the liquid as a result of a reduction of the volume because of the cooling. Measurements will be conducted at MARUM.

5.2.5.5 Nutrients

(Geert-Jan Brummer and Jacqueline Bertlich)

A total of 237 nutrient samples were taken from the Niskin water sample bottle of both the MPS and the shipboard CTD water sampler rosette (Appendix table 11.7). A sea water subsample was transferred to two 6 ml-HDPE “Ponyvials”, filled to 80% and capped. One subsample was frozen for later analysis of the dissolved phosphate, nitrate and nitrite concentrations, the other was stored cool for later analysis of dissolved silica concentration. The samples will be analysed at Royal NIOZ.

5.3 Moorings

5.3.1 Dust collecting buoys

(Jan Berend Stuut)

Autonomous dust-collecting buoys were constructed at NIOZ, in close collaboration with MARUM technicians who had ample experience with floating measurement platforms after having operated the ESTOC station for many years (Neuer et al., 1997). The dust-collecting buoys were deployed for the first time in 2013 during cruise 64PE378 on board RV Pelagia. At the time there were three PhD students: Carmen Friese, Michèlle van der Does and Laura Korte, who all had a buoy named after them. During cruise JC134 on board RRS James Cook in 2016, two dust-collecting buoys were deployed: buoy Laura at about 12°N/23°W and buoy Carmen at about 21°N/21°W. During cruise M140 on board FS Meteor, these two buoys were to be recovered, serviced and re-deployed.

Of both buoys the parts below the water line were completely overgrown with algae and gooseneck barnacles and this bio-film obviously supplied a micro-habitat/food chain with large fish as top-predators. The towers of the buoys were covered in dust.

The sampling protocol of the buoys involves a set of requirements that have to be met before the inlet of the tower is opened and air is pumped through filters. First of all, it may not rain as we only want to sample dust transport at dry conditions. Second, to prevent sampling of salt/spray, the wind speed measured by the Vaisala® weather station should not exceed 20 m/s. When these requirements are met for at least 1 hour, the air inlet opens and air is pumped into the sampling chamber with 47mm polycarbonate filters for 4 hours per day, resulting in about 1200 L per sampling session. Each filter sampled for 24 days, resulting in about 28,000 L per filter. All data (meteorological conditions, position but also amount of air being pumped through the filters) are sent home twice a day through an iridium connection.

Buoy Laura was re-deployed on 24 August 2017, at 11°25’N / 22°56’W at a water depth of 5116m. Buoy Carmen was re-deployed five days later, at 21°15’N / 20°59’W at a water depth of 4225m.

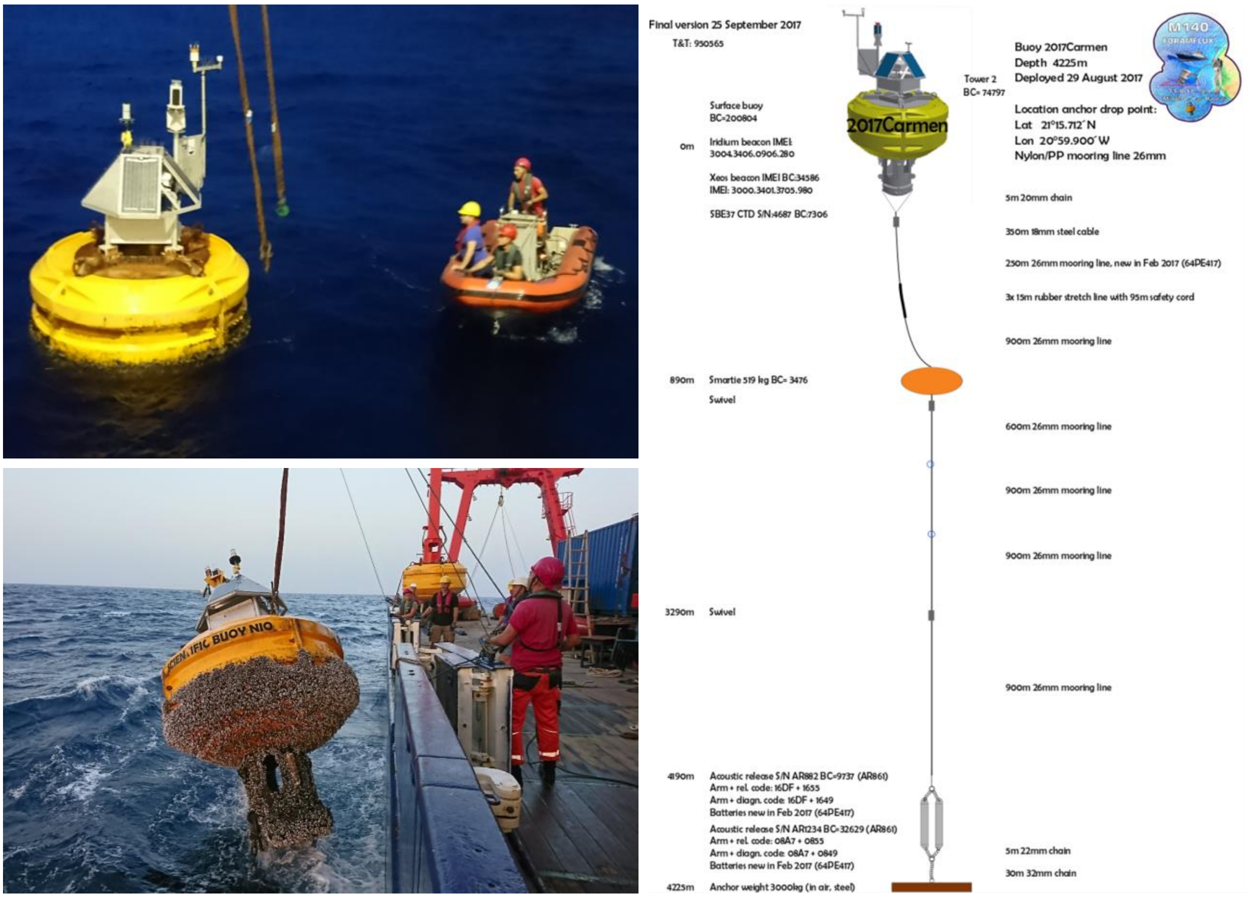

Figure 5.19: Buoy Laura is about to be recovered. From the life boat, two hooks were fixed to the buoy, after which she was gently hoisted on board. (upper panel, left); Recovery of buoy Carmen. This time the sea-state did not allow a recovery from the life boat. Instead, a line was fixed to one hook on the buoy, after which she was hoisted on board. Clearly, she gained some weight from all the gooseneck barnacles. (lower panel, left); Technical layout of buoy Carmen. (right panel)

5.3.2 Moored sediment traps

5.3.2.2 Central Atlantic mooring arrays

(Geert-Jan Brummer and Jan-Berend Stuut)

One of the goals of cruise M140 was the recovery, servicing and redeployment of long-term moorings on a transect along 12°N in the equatorial North Atlantic Ocean. These sub-surface moorings were first deployed in October 2012 and serviced every year within the TRAFFIC and DUST-TRAFFIC programs focused on the transport, deposition and marine environmental effects of Saharan dust. Originally a total of five moorings (M1 through M5) was deployed along the transect, each equipped with ADCPs, current meters and T-S sensors and two large sediment traps (PPS 5/2) with tilt meters. For the FORAMFLUX project, two of the moorings were re-deployed in April 2016 (M3 and M1) during cruise JC134 of the RV James Cook, to be recovered during cruise M140 of the FS Meteor. Both moorings were designed to operate in a synchronised time-series (see below), extending the particle flux record previously obtained. Moreover, mooring 16M1 was designed to sample at unprecedented resolution of four days for a full year using three sediment traps in one continuous time-series, in order to (1) resolve Saharan dust deposition from individual dust storms, and (2) to resolve (semi)lunar reproductive cycles in the shell flux of planktonic foraminifera.

Table 5.5: Instrument details of equipment recovered during M140.

Sta-tion	Depth [m]	Instrument	Serial No.	Barcode	Start date
M3	842	XEOS Iridium beacon		3944	
		XEOS flash unit		40860	
	1242	Sediment trap PPS	046	8488	06/04/2016
		Motor unit	9-265	35354	
		Tilt data logger	C1	12171	
		FLNTU	2855	74551	
		SBE 37 MicroCat	4345	12805	
	3534	Sediment trap PPS	91-27	9836	06/04/2016
		Motor unit	11-282	72007	
		SBE 37 MicroCat	2657	3803	[P-sensor broken)
	4660	IXSEA Acoustic releasers AR861	167	826	
			156	2981	
	4665	Anchor weight (bottom)			
M1	980	XEOS Iridium beacon		39437	
	1053	Sediment trap KUM	2014420	60257	01/04/2017
		KUM electr. Unit	2014420	39802	
		KUM motor 1	2014420A	39796	
		KUM motor 2	2014420B	39772	
		Tilt data loger	BD	9416	
		SBE 37 MicroCat	4140	5050	
	1149	Sediment trap KUM	2014422	60264	02/12/2016
		KUM electr. Unit	2014422	39765	
		KUM motor 1	2014422A	39741	
		KUM motor 2	2014422B	39727	
		Tilt data logger	C4	9522	
		SBE 37 MicroCat	4351	12768	
	1264	Sediment trap KUM	2014421	60240	18/04/2016
		KUM electr. Unit	2014421	39789	
		KUM motor 1	2014421A	39758	
		KUM motor 2	2014421B	39734	
	5060	IXSEA Acoustic releasers AR861	175	3001	
			156	11211	
	5065	Anchor weight (bottom)			

Mooring 16M3 was successfully recovered despite initial communication problems with both IX-SEA releases. It was equipped with two Technicap PPS-5/2 traps (collecting area 1.0 m^2, 1 cm^2 honeycomb baffle and 24 collecting bottles each), the upper one at 1242m depth (16M3U) and the lower one at 3534m (16M3L), each provided with tilt-pressure sensors and Microcat-CTDs (see Table 5.5). Upon recovery, it appeared that four bottles were missing from the upper trap (16M3U-4, -6, -8, -16), three were damaged (16M3U-7, -9, -10) but their content apparently intact, and

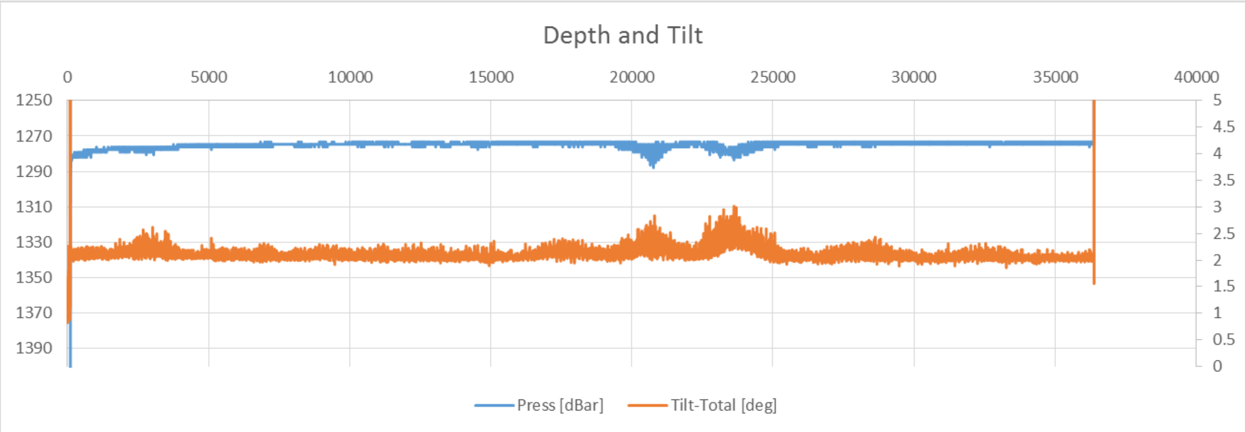

Figure 5.20: Pressure and tilt measured during the deployment of the 1200m trap at M3 (16M3U).

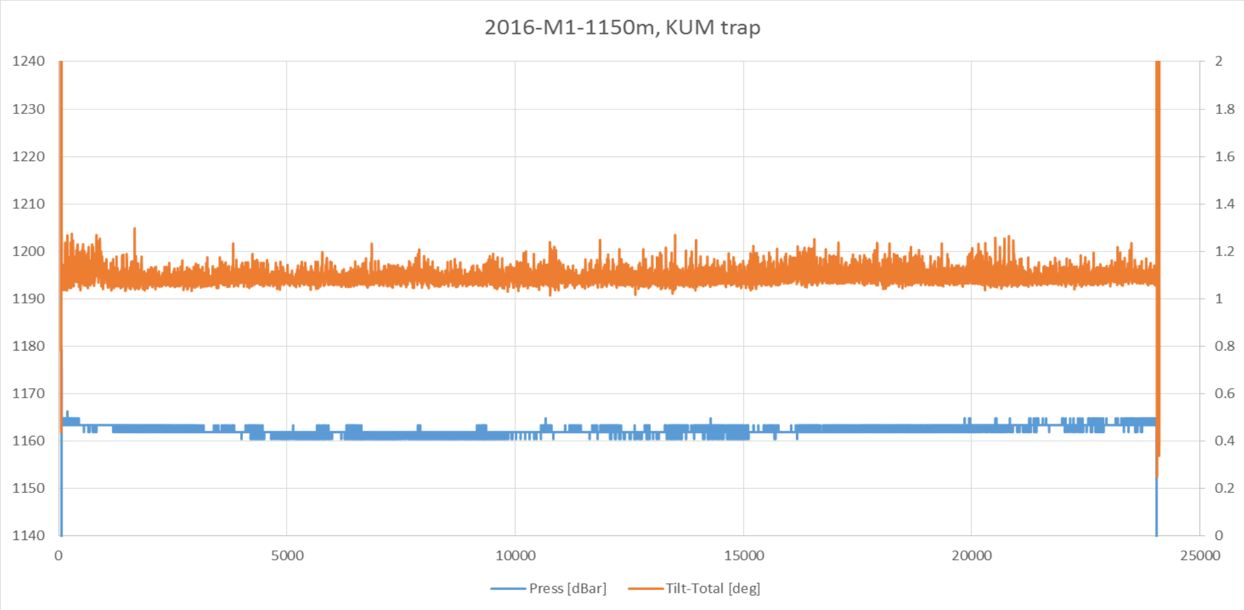

Figure 5.21: Pressure and tilt measured during the deployment of the 1050m and 1150m trap at M1 (16M1U).

another three were only loosely attached to the carrousel. This could be traced back to the interaction between the shackles just below the mooring spar and the carrousel with collecting bottles during deployment, something that can easily be prevented during future operations. The read-out from the trap motor software confirmed that the upper trap completed the rotation schedule as programmed, but that the lower trap (16M3L) had skipped the first interval, so that bottle #1 collected the flux during interval #2, bottle#2 the flux of interval #3, etc., so that the carrousel stopped rotating at bottle #24. Probably during recovery, bottle #24 was blown off the carrousel as it was missing when the trap surfaced. For the rotation schedule and further details, see table 11.8. The tilt-pressure data showed that both traps remained vertical with occasional excursions of less than 1.5° (equating to less than 15m in depth), indicating that particle collecting efficiency was not compromised during the deployment period (Fig. 5.20). Upon arrival on deck, the entire carrousel with sample bottles was dismounted from each trap, and transferred to the chemistry laboratory. 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 2.23 g/L) and a pH-buffer (Borax; $Na_2B_4O_7x10H_2O$; end concentration 1.29 g/L) had been added, which also created a density slightly in excess of the ambient seawater. For shipboard processing of the Technicap traps (16M3), the sample carrousel was put on top of a stable stand for safe manual rotation of the carrousel. After slight loosening of the four bolts, the carrousel was manually rotated to the first sample position to remove the top 35 mL of supernatant solution from the connecting neck with an all-PP syringe, and transferred to a 40 mL PP bottle for later analysis of the pH and nutrient composition. This procedure was repeated until the supernatant solution was removed from the connecting neck above each of the 24 sample bottles of the trap carrousel, so that all sample bottles could safely be removed from the carrousel, capped, and stored at 4 °C for the duration of the cruise. For a first order estimate of the mass flux, the height of the residue in the collecting bottles was measured (Appendix table 11.8).

Mooring 16M1 was successfully recovered, again despite initial communication problems with the IXSEA releases. It was equipped with three KUM traps, each with a collecting area 0.5 m^2, a 1 cm^2 honeycomb baffle and 39 collecting bottles in two carrousels each. These were deployed 100 m apart at 1050m (16M1U), 1150 m (16M1M) and 1250 m (16M1L), the upper two equipped with tilt-pressure sensors and Microcat-CTDs (see Table 5.5). Upon recovery, it appeared that the lowermost trap sampled only 23 of the 39 programmed intervals, but that both the middle and upper trap sampled as programmed (Appendix table 11.9). Given previous rotation failures associated with these KUM-traps, this was much better than expected. In total 260 consecutive days were sampled at 4 day resolution: an unprecedented record from the open ocean. Moreover, the tilt-pressure data showed that all traps remained perfectly vertical throughout the entire deployment period (Fig. 5.20). Upon arrival on deck, all 90 bottles that had been sampling were unscrewed individually on deck, capped, and stored at 4°C for the duration of the cruise. 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 1.97 g/L) and a pH-buffer (Borax; $Na_2B_4O_7x10H_2O$; end concentration 1.29 g/L) had been added, which also created a density slightly in excess of the ambient seawater. For a first order estimate of the mass flux, the height of the residue in the collecting bottles was measured (Appendix table 11.9).

At the M1, the mooring (17M1) was redeployed at the same site and according to the same design as 16M1, but not after some important modification of the electronics of each of the three KUM sediment traps. This was done to ensure more battery power went to the motors to minimise rotation failures. Sample cups were filled with seawater collected from a ship-board CTD rosette at the deployment depth of each trap, to which a biocide ($HgCl_2$) and a pH-buffer ($Na_2B_4O_7x10H_2O$, Borax) were added, to create a solution with a density slightly in excess of the ambient seawater. Per trap, 17 grams of $HgCl_2$ was dissolved in 300 mL of Milli-Q and 100 mL of seawater, of which 10 mL was pipetted in each of the collecting bottles. Per trap, 34 grams of Borax was dissolved in 800 mL milli-Q, of which 20 mL was pipetted in each collecting bottle. All bottles were filled with seawater to their brim capacity (430ml) and screwed under each trap. All bottles that failed to sample during the previous deployment were re-used including their original solution in order to minimise the production of toxic waste, i.e. 16M1U-30 through -39 and 16M1L-24 through -39 (Table 5.4). Similar to the previous deployment (i.e. 16M1), the rotation schedule was programmed for consecutive sampling at a resolution of 4 days per bottle, starting on August 27 (12:00 hours) and ending December 8, 2018 (Appendix table 11.10), i.e. until the expected time of recovery with RV Maria S. Merian in early November 2018.

5.3.2.3 Cape Blanc mooring array

(Gerhard Fischer, Götz Ruhland and Marco Klann)

The CB mooring with sediment traps, located about 210 nm off Cape Blanc, has been operated as a long-term monitoring site by the University of Bremen since 1988. It is situated in a mesotrophic area at the edge of the Cape Blanc filament in about 4150 m water depth. The mooring array is used to monitor the long-term and short term variability of particle fluxes in the Mauritanian offshore upwelling zone. The last deployment of the mooring (CB-28) took place during the Poseidon POS-508 cruise in January 2017, together with the deployment of a second mooring located about120 nm further to the east (CBi-15). Both moorings were scheduled for service during the M140 cruise. The layout and details of deployments and recoveries of the moorings are shown and listed in figure 5.22 and table 5.6 alongside with the sampling data of the traps.

The 3100 m long mooring array CB-28 was released in the afternoon of August 28th, 2017. This mooring was equipped with two standard particle sediment traps each with an installed sampling carousel of twenty bottles. Two sets of samples of CB-28 could be received, each with 20 samples

Table 5.6: Details for recoveries and redeployments of the Cape Blanc particle trap mooring arrays

Mooring	Position	Water depth [m]	Interval	Instrument	Depth [m]	Intervals (no x days)
Mooring recoveries:						
CB-28 (mesotrophic)	21°12.57'N	4154	22.02.16-	BioOpticalPlatform		
GeoB 22414-6	020° 52.64'W		27.04.2017	SMT243NE	1201	1x8.5d,19x10.5d
				SMT234NE	3616	1x8.5d,19x10.5d
CBi-15 (eutrophic)	20° 52.08'N	2751	25.02.16-	SMT234NE	1356	20x10.5d
GeoB 22416-1	018° 45.37'W		27.04.2017	SMT234NE	1913	20x10.5d
Mooring deployments:						
CB-29 (mesotrophic)	21°14.96'N	4150	31.08.17-	S/MT234NE	1118	20x4d (foram trap)
GeoB 22415-1	020°51.66'W		30.11.2018	S/MT234NE	1223	19x22d, 1x38d
				S/MT234NE	3629	19x22d, 1x38d
CBi-16 (eutrophic)	20°50.70'N	2750	02.09.17-	S/MT234NE	1253	1x20d,18x22d,1x38d
GeoB 22420-1	018°44.60'W		30.11.2018	S/MT234NE	1858f	1x20d,18x22d,1x38d

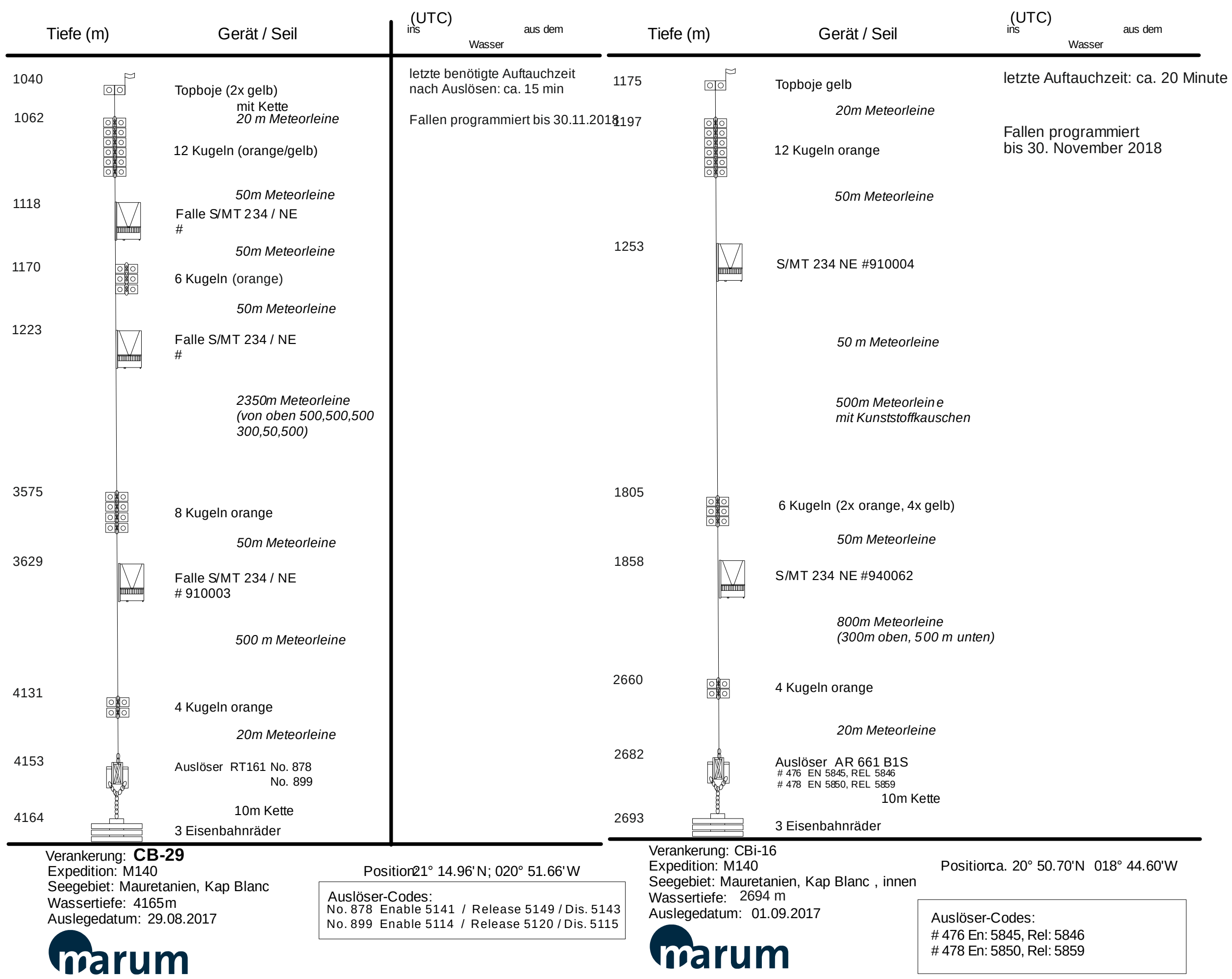

Figure 5.22: Layouts of the sediment trap deployments CB 29 and CBi 16.

due to the programming schedule of the traps. Additionally, the mooring was equipped with a newly developed Bio-Optical Platform (BOP) equipped with a particle camera and a 40 cup sampling system for sinking particles. Sampling cups contained gels to preserve the original shape and size of sinking marine snow particles which are otherwise lost with standard sediment trap sampling. In the afternoon of August 29th, 2017, the mooring array CB-29 could be redeployed. However, instead of the BOP system, another particle sediment trap for foraminiferal studies was deployed in the mooring, allowing sampling of particle and planktonic foraminifera flux in the more productive area off Mauritania at 4-day resolution, which equals a total collection duration of 80 days in summer and fall 2017. The next morning, August 30th, 2017, CBi-15 could be recovered. Both installed particle traps had worked continuously and 2x20 samples could be recovered showing high mass fluxes at this site. The mooring was redeployed as CBi-16 with a similar configuration of traps two days later on September 1st, 2017 within 1.5 hours. It is planned to recover and redeploy these two moorings with RV Maria S. Merian in November 2018.

5.3.2.3.1 BioOptical Platform

(Morten Iversen and Christian Konrad)

The BioOptical Platform (BOP) is an in-house (MARUM) developed instrument allowing us to follow aggregate dynamics throughout a whole year. It uses an optical system to determine size-distribution, abundance and size-specific sinking velocities of settling particles every day throughout a whole year. Additionally, it collects the settling particles in a viscous gel over different time intervals throughout the year. The BOP system is based on a modified sediment trap (*Fa. KUM GmbH*) where we have replaced the collection funnel with a polycarbonate cylinder to avoid that the settling particles are sliding down the sides of the funnel, which would change their physical structure. The polycarbonate cylinder has an inner diameter of 35 mm and functions as a settling column and allows us to measure the settling velocities and sizes of the particles without interference from ocean currents (Fig. 5.23). This is done with a camera system that is placed in the lower part of the settling column. The camera system consists of an industrial camera (*Fa. Basler*), a fixed focal length lens (*Fa. Edmund Optics*) and the system electronics consisting of single board

Figure 5.23: The BOP system with the polycarbonate settling column (left) and the two rotation tables (center). Camera System on BOP with the camera housing (for camera, lens and system electronics), the visible back-light source and the Li-Ion battery (right).

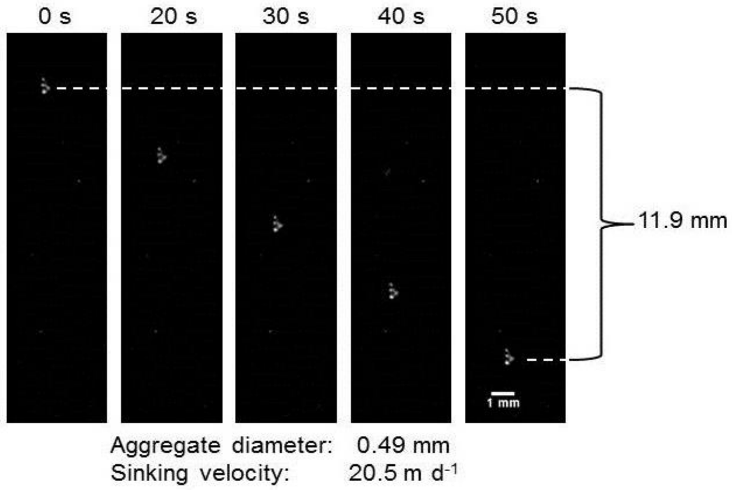

Figure 5.24: Example of a sinking aggregate captured in the settling column of BOP during the 1st of February 2017

computer including a SSD hard disc and custom made power and time management circuitry. The images are illuminated by a custom made visible light source providing backlight (Fig. 5.23). The whole camera system is powered by a Li-Ion battery (24V, 1670Wh, *Fa. SubCTech GmbH*). The camera system makes 5 min of recordings every day. Once the particles have settled through the settling column they are collected in cups filled with a viscous gel that preserves their size and physical structure. The gel cups are placed on two rotation tables capable of carrying 40 gel cups (Fig. 5.23).

The geometrical configuration of the camera system enables daily recordings of shadow images of the particles within the settling column throughout a whole year. It was programmed to take sequences of one image per second for five minutes twice every day throughout one year. The system was deployed as part of the CB-28 mooring at 2930m during PSO508. The recovery of BOP system on CB-28 during this cruise was successful the system was in good shape. The camera system was acquiring data from 26th January 2017 until 20th of May 2017 successfully. It is yet unclear why exactly the system stopped operation at that date. Still, a first look on the data showed many successful sequences, where we could observe particles sinking. The collection of sinking particles in the gel traps only worked for the bottom rotation table while the upper rotation table failed to rotate. Still, all the gel-cups on the bottom table had collected settling aggregates. The optical sequences with settling aggregates will be used to analyse the sinking velocities for each captured interval and relate the sinking velocities to the sizes and composition of the aggregates. Preliminary analysis of the images reinforces the usability of the method. For example, on the 1st of February 2017 the BOP images imply typical sinking velocities of around 20 m d^{-1} (Fig. 5.24). From the gel-cup collection we identified that the aggregates during that period consisted of tintinids, degraded faecal pellets, and pennate and centric diatoms.

5.3.3 Test mooring

(Jan Berend Stuut, Yvo Witte)

Through the years, there have been large technological developments in mooring techniques. Always, the community strives for optimal results

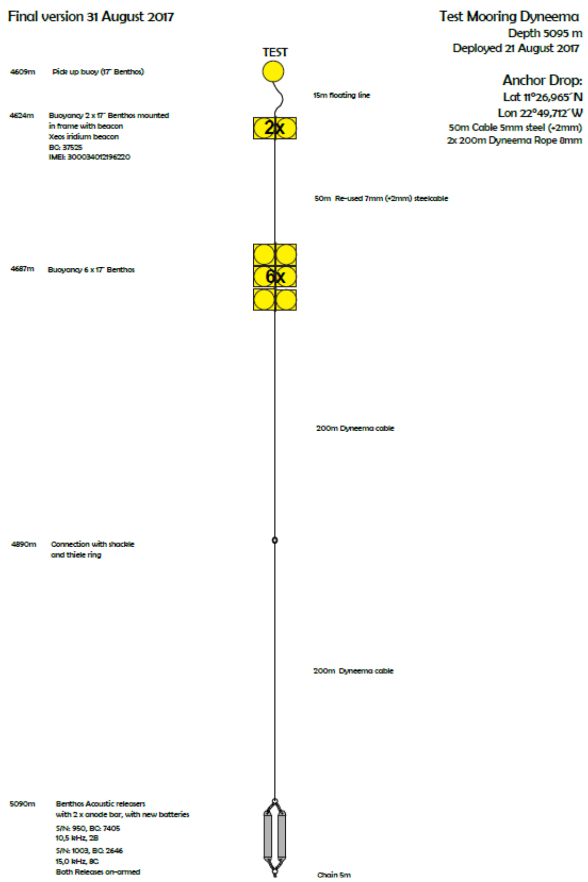

Figure 5.25: Technical layout of the test mooring

like, e.g., using specific types of cables tuned to the deployed instruments; coated steel cables for sediment traps, Kevlar cables for trace-metal clean sampling, etc. In addition, we always strive for maximum cost effectiveness but foremost safety. So far, we are used to replacing the plastic-coated steel cables regularly, so as to avoid breaking of the cable during deployment or recovery. With the development of new materials, we now have the opportunity to use Dyneema lines, which have a lot of advantages; they are thin, leading to less drag forces on the mooring, they are strong (5500kg max loading as opposed to 3900 for steel cables) and they are less prone to wear. The only thing that we don't know yet is their long-term behavior in terms of degradation of weight bearing ability during deployment. For this reason, a test mooring was designed with two 250m pieces of Dyneema line. The mooring was deployed in the vicinity, yet not too close, to station M1. In the coming years, this test mooring will be serviced and pieces of line shall be exchanged and monitored for their resistance to wear. For details of the test mooring, please see technical sketch (Fig. 5.25).

5.4 ARGO floats

(Michael Siccha)

The Bundesamt für Seeschifffahrt und Hydrographie (BSH) provided the cruise with five ARGO floats that were to be deployed at defined positions (Table 5.7, desired coordinates supplied by BSH) along the cruise track. All floats were of type ARVOR-33-16-026_UTI form *nke Instrumentation* and measurement parameters were programmed by BSH.

Table 5.7: Details of the five Argo deployments during M140.

Argos ID	S/N	Longitude [°]	Latitude [°]	Date [UTC]	Time [UTC]
170351	AL2500017DE015	22° 51.37' W	11° 27.84'N	24/8/2017	16:03
170352	AL2500017DE016	28° 59.76' W	11° 47.55' N	19/8/2017	19:34
170353	AL2500017DE017	38° 39.29' W	12° 22.52' N	16/8/2017	22:23
170354	AL2500017DE018	21° 32.09' W	20° 39.64' N	27/8/2017	21:59
170355	AL2500017DE019	17° 37.67' W	22° 59.11' N	2/9/2017	10:00

5.5 Atmospheric dust sampling

(Jan-Berend Stuut)

During M140, the long-term programme of NIOZ to monitor atmospheric mineral dust deposition was continued. Mineral dust emission, transport, and deposition are monitored in order to: *(i)* assess its role(s) in climate feedback mechanisms, *(ii)* provide data for climate models, and *(iii)* interpret dust deposits in marine sediment cores with respect to past-climate reconstructions. Both dust transport and deposition are studied by filtering air and by collecting rain at sea. Dust particles play an important role in cloud formation as they can act as cloud-condensation nuclei (CCN). In the CCN process, the particles are exposed to organic acids, which leach metals and nutrients from the particles, thus increasing the bio-availability of these metals and nutrients for marine plankton. Therefore, we are very interested in this so-called "wet-deposited dust". As rain at the lower latitudes usually occurs around August and September, we hoped to also collect dust that has been washed out from the atmosphere by rain. In addition to active dust sampling, we installed for the first time a passive rain sampler, using a plastic box with dimensions H x W x L = 42 x 56 x 36cm.

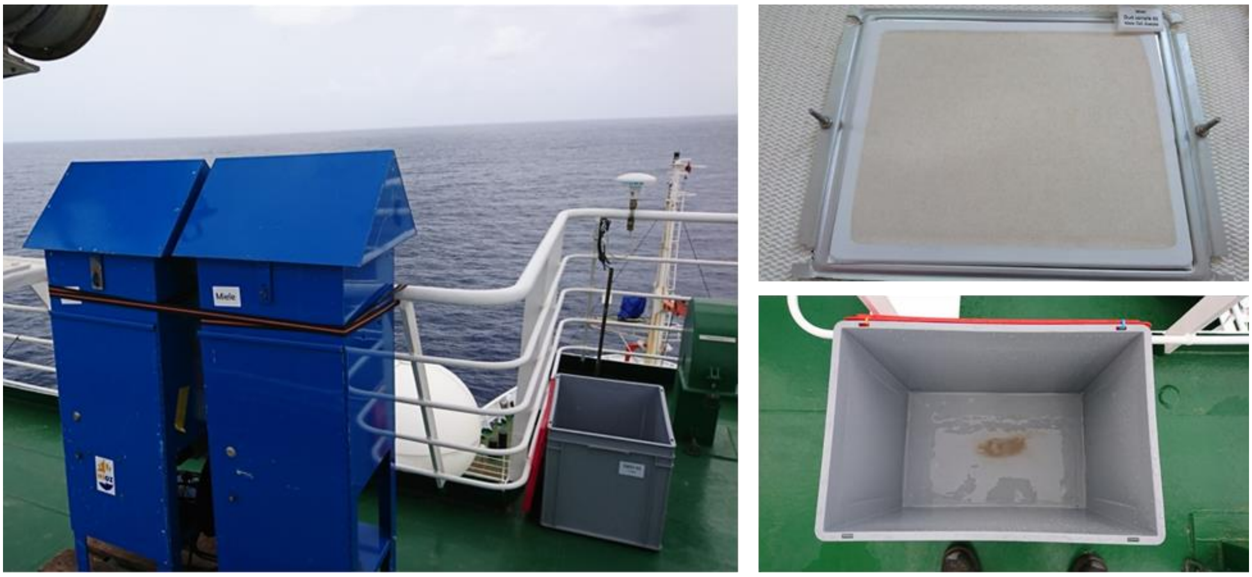

Figure 5.26: Two Anderson® Hi-Volume dust samplers (blue) and the passive rain sampler (grey box); Dust sample 2: orange-colouration on a Cellulose Acetate filter; Dust sample 4: orange-material in rainwater

Rainwater sampling was carried out at times when rain was forecasted or seen on the horizon, or when dust was observed either on satellite images or on the dust filters. We also successfully sampled two individual rain showers during this cruise. As hypothesized, the rain showers wash down huge amounts of dust (Fig. 5.26, lower right).

Generally, we sampled both dry- and wet dust in 24-hour intervals (Table 5.8). During periods of ongoing rainfall, we did not sample the dry deposition as the atmosphere had been washed clear of dust. Preliminary analysis of the dust collection confirms that M140 passed through two large Saharan dust outbreaks, one that occurred directly at the start of the cruise (11 August onwards) and another one when approaching São Vicente for the second time (around 27 August).

Table 5.8: Overview of dust samples collected by air sampling

Station		Sampling							
		Start				End			Remarks
Nr.	Date	Time	Lat °N	Lon °W	Date	Time	Lat °N	Lon °W	Yield: low = ☹, high = ☺
D1	11.08	11:15	16°28.96'	26°12.62'	12.08	9:30	15°52.25'	28°44.71'	10.5 hr, ☺
D2	12.08	9:45	15°52.25'	28°44.71'	13.08	9:30	14°47.42'	32°31.26'	20.9 hr, ☺
D3	13.08	9:45	14°47.42'	32°31.26'	14.08	8:55	13°43.33'	36°13.05'	9.1 hr, wet dust ☺
D4	17.08	18:00	12°15.20'	35°44.27'	18.08	9:00	12°05.82'	35°47.10'	wet dust only ☹
D5	18.08	9:15	12°05.82'	35°47.10'	19.08	8:30	11°52.95'	30°23.52'	20.7 hr, dry + wet dust ☹
D6	19.08	9:00	11°52.95'	30°23.52'	21.08	8:30	11°31.67'	23°06.10'	3.5 hr, dry + wet dust ☹
D7	21.08	08:30	11°31.67'	23°06.10'	22.08	8:30	11°25.05'	22°56.01'	18.8 hr, dry + wet dust ☹
D8	22.08	08:45	11°25.05'	22°56.01'	24.08	9:00	11°26.85'	22°55.87'	7.9 hr, dry + wet dust ☹
D9	24.08	11:05	11°26.85'	22°55.87'	25.08	11:00	11°25.05'	22°56.01'	19.2 hr, dry + wet dust ☹
D10	25.08	11:15	11°25.05'	22°56.01'	24.08	9:00	11°26.85'	22°55.87'	7.9 hr, dry + wet dust ☹
D11	26.08	14:00	17°11.27'	24°47.00'	27.08	10:10	19°31.35'	22°35.31'	7.9 hr, dry + wet dust ☹
D12	27.08	10:25	19°31.35'	22°35.31'	28.08	12:05	21°13.54'	20°54.08'	25.1 hr, dry + wet dust ☺
D13	28.08	12:20	21°13.54'	20°54.08'	29.08	12:55	21°14.72'	20°56.29'	22.8 hr, dry dust only ☺
D14	29.08	13:10	21°14.72'	20°56.29'	30.08	13:45	20°50.66'	18°47.60'	21.6 hr, dry dust only ☹
D15	30.08	14:00	20°50.66'	18°47.60'	31.08	13:15	20°49.05'	18°52.46'	21.6 hr, dry dust only ☹
D16	31.08	13:30	20°49.05'	18°52.46'	01.09	17:00	21°14.72'	20°56.29'	25.9 hr, dry dust only ☹

6 Ship's meteorological station

The RV METEOR left the port of Mindelo in the morning hours of 11. August 2017. It was a mostly cloudy sky and under the protection of Isle Santo Antão winds were only light and variable. Until the 15th RV METEOR was on a southwesterly course to the first mooring station at 13N 39W. At first, northeasterly trade winds about 3 Bft, later 4 to 5 Bft within a weak pressure gradient were experienced. The significant wave height showed 1 to 1.5m at first with only a little contribution of the windsea. Later it climbed to 1.5m with a swell from a northerly direction. As RV METEOR approached the intertropical convergence (ITC), the first showers with about 34mm in 12 hours were measured on the 14th (14N 36W). The wind was weak and variable, mostly about 3 to 4Bft, the swell showed direction from the N to NE and S. In the working area M3 (12N39W) tropical disturbances from the east crossed regularly. They were triggered by easterly upper winds. From the 17th to the 21st on the way to the next working area M1 along 12N to 23 W the wind and sea conditions did not change much. However, on the 20th due to an intrusion of dry air, no precipitation was measured. On the evening of the 21th in the eastern working area, sheet lightning was observed, indicating a higher potential for convection in the area. The southwest to west wind was about 4 Bft, during showers gusts of 8 Bft were measured. The significant wave height increased to 2m. On the 23rd, a heavy shower was registered, in 25 minutes the rain gauge showed 38 mm accompanied by gusts of 36kt. After a short circuit the data registration stopped due to some water intrusion into the meteorological office. On the 24th after the last work done another heavy shower with 29mm in 30 minutes was registered while RV METEOR was heading to the harbor of Mindelo. Southerly winds about 3 Bft with a sea of 1 to 1.5 m were experienced at first however while cruising through southern islands of Cabo Verde a weak jet effect occurred. Later on the way to Mindelo the wind was weak with an almost flat sea with only about 1m of swell. In the evening a weak shower and sheet lightning to the east indicated a labilization of the overlaying air masses. On the evening of the 26th, to the north of the islands, the weak wind picked up to 4 Bft and the almost flat sea started to show significant wave height of 1.5 m. Even in the almost dry northeast trade wind area, a weak shower brought 3 mm with the result of washing out the Sahara dust and improving the visibility. On the 28th, in the working area to the northeast of the islands on the northeastern flank of the Azores high the northeasterly trade winds about 5 Bft set in with a significant sea of about 2 m. Whilst approaching the African continent, the northeasterly winds increased steadily to 6 Bft with the significant wave height up to 2 to 3m due the thermal low over the mainland and the little strengthening of the Azores high. From the 1st of September, on transit to Las Palmas, the sea decreased to around 2m with the wind dropping around 5 Bft. Apart from jet and lee effects the conditions did not change much on the way to the Canary Islands. The water temperature in the working area was about 2 Kelvin above the average values from 1998 (Source: BSH atlas). In the early morning hours of the 05th of September the RV METEOR reached the port of Las Palmas on the Canary Islands with northeasterly winds of about 5 Bft.

7 Station list

Table 7.1. List of stations and deployments during cruise M140. For floating traps and moorings, D indicates deployment and R indicates recovery.

Station data							Devices					
Station	GeoB No.	Date [UTC]	Time [UTC]	Latitude	Longitude	Depth [m]	A	CTD	DT	M	MPS	PC
984-1	22401-01	11.08.2017	16:28	16° 38,88' N	026° 00,86' W	4328,4					X	
985-1	22402-01	12.08.2017	09:07	15° 52,24' N	028° 44,71' W	5140,8					X	
985-2	22402-02	12.08.2017	10:11	15° 52,24' N	028° 44,71' W	5136,2					X	
985-3	22402-03	12.08.2017	10:34	15° 52,25' N	028° 44,71' W	5140,3					X	
986-1	22403-01	13.08.2017	09:36	14° 47,44' N	032° 30,40' W	5798,5					X	
986-2	22403-02	13.08.2017	10:35	14° 47,40' N	032° 31,13' W	5808,1					X	
986-3	22403-03	13.08.2017	10:55	14° 47,40' N	032° 31,38' W	5810,4					X	
987-1	22404-01	14.08.2017	09:31	13° 43,25' N	036° 12,91' W	5537,2					X	
987-2	22404-02	14.08.2017	10:32	13° 43,43' N	036° 13,21' W	5489,1					X	
987-3	22404-03	14.08.2017	10:53	13° 43,49' N	036° 13,27' W	5471,7					X	
988-1	NA	15.08.2017	08:01	12° 20,75' N	038° 52,19' W	4921,0				R		
989-1	NA	15.08.2017	14:35	12° 23,88' N	038° 38,24' W	4693,9			D			
990-1	22405-01	15.08.2017	15:40	12° 24,66' N	038° 38,08' W	4748,2					X	
991-1	22405-02	15.08.2017	16:24	12° 25,40’ N	038° 40,40’ W	5077,3					X	
992-1	22405-03	15.08.2017	17:07	12° 26,04' N	038° 39,92' W	5030,4					X	
993-1	22405-04	15.08.2017	17:35	12° 26,54' N	038° 39,88' W	5055,0					X	
994-1	22405-05	15.08.2017	18:10	12° 27,02' N	038° 40,26' W	5135,3					X	
995-1	22405-06	15.08.2017	18:51	12° 26,30’ N	038° 38,37’ W	4949,1					X	
996-1	22405-07	15.08.2017	19:28	12° 27,43' N	038° 38,47' W	5166,4					X	
997-1	22405-08	15.08.2017	20:08	12° 27,61' N	038° 36,39' W	4860,7					X	
998-1	22405-09	15.08.2017	20:51	12° 28,84’ N	038° 37,13’ W	5128,8					X	
999-1	22405-10	15.08.2017	21:27	12° 30,62’ N	038° 36,87’ W	5366,9					X	
1000-1	22405-11	15.08.2017	22:15	12° 30,24' N	038° 35,33' W	5134,9					X	
1001-1	22405-12	15.08.2017	22:53	12° 32,09’ N	038° 36,34’ W	5461,3					X	
1002-1	22405-13	15.08.2017	23:39	12° 32,15’ N	038° 37,97’ W	5412,8					X	
1003-1	22405-14	16.08.2017	00:15	12° 30,03' N	038° 38,22' W	5315,6					X	
1004-1	22405-15	16.08.2017	00:59	12° 31,57’ N	038° 38,90’ W	5413,8					X	
1005-1	22405-16	16.08.2017	01:29	12° 31,95' N	038° 39,88' W	5547,3					X	
1006-1	22405-17	16.08.2017	02:06	12° 31,74' N	038° 40,62' W	5435,3					X	
1007-1	22405-18	16.08.2017	02:39	12° 32,79' N	038° 40,48' W	5512,7					X	
1008-1	22405-19	16.08.2017	03:16	12° 32,49’ N	038° 40,08’ W	5558,3					X	
1009-1	22405-20	16.08.2017	03:50	12° 33,05’ N	038° 39,44’ W	5582,1					X	
1010-1	22405-21	16.08.2017	04:39	12° 32,76' N	038° 37,39' W	5530,0					X	
1011-1	22405-22	16.08.2017	05:16	12° 32,39’ N	038° 35,39’ W	5316,2					X	
1012-1	22405-23	16.08.2017	05:49	12° 32,72’ N	038° 35,43’ W	5432,1					X	
1013-1	22405-24	16.08.2017	06:28	12° 32,46’ N	038° 33,60’ W	5364,1					X	
1014-1	22405-25	16.08.2017	07:05	12° 31,69' N	038° 33,43' W	5340,8					X	
1015-1	22405-26	16.08.2017	07:41	12° 32,44' N	038° 32,01' W	5583,0					X	
1016-1	22405-27	16.08.2017	08:20	12° 31,32' N	038° 31,19' W	5567,0					X	
1017-1	22405-28	16.08.2017	08:45	12° 31,15' N	038° 30,94' W	5563,4					X	
1018-1	22405-29	16.08.2017	09:30	12° 30,54' N	038° 30,83' W	5495,8					X	
1019-1	22405-30	16.08.2017	10:02	12° 29,91’ N	038° 31,40’ W	5471,6					X	
1020-1	22405-31	16.08.2017	10:50	12° 29,28' N	038° 32,57' W	5200,5					X	
1021-1	22405-32	16.08.2017	11:14	12° 29,54' N	038° 32,88' W	5202,1					X	
1022-1	22405-33	16.08.2017	11:52	12° 29,03' N	038° 34,19' W	5087,5					X	
1023-1	22405-34	16.08.2017	12:29	12° 28,29' N	038° 32,81' W	5165,1					X	
1024-1	22405-35	16.08.2017	13:10	12° 27,50’ N	038° 32,68’ W	5247,7					X	
1025-1	22405-36	16.08.2017	13:56	12° 26,14' N	038° 35,32' W	4746,9					X	
1026-1	22405-37	16.08.2017	14:32	12° 25,78’ N	038° 35,51’ W	4743,2					X	
1027-1	22405-38	16.08.2017	15:06	12° 25,45’ N	038° 34,65’ W	4791,7					X	
1028-1	22405-39	16.08.2017	15:57	12° 23,10' N	038° 34,67' W	4740,1					X	
1029-1	22405-40	16.08.2017	16:41	12° 23,30’ N	038° 36,36’ W	4721,1					X	
1030-1	22405-41	16.08.2017	17:07	12° 23,03' N	038° 36,83' W	4718,0					X	
1031-1	NA	16.08.2017	17:53	12° 22,24' N	038° 35,66' W	4645,3			R			
1032-1	NA	16.08.2017	18:06	12° 22,22' N	038° 35,83' W	NA				R		
1033-1	NA	16.08.2017	22:23	12° 22,52' N	038° 39,29' W	4771,3	X					
1034-1	22406-01	17.08.2017	09:35	12° 17,58' N	036° 56,55' W	5410,3					X	
1034-2	22406-02	17.08.2017	10:38	12° 17,59' N	036° 56,63' W	5405,9					X	
1034-3	22406-03	17.08.2017	10:55	12° 17,66' N	036° 56,70' W	5409,8					X	

1035-1	22407-01	18.08.2017	09:30	12° 05,75' N	033° 47,10' W	5989,9					X	
1035-2	22407-02	18.08.2017	10:44	12° 05,93' N	033° 47,57' W	6031,7					X	
1035-3	22407-03	18.08.2017	11:08	12° 05,98' N	033° 47,70' W	6049,3					X	
1036-1	22408-01	19.08.2017	09:32	11° 52,85' N	030° 22,61' W	5752,5					X	
1036-2	22408-02	19.08.2017	10:33	11° 52,83' N	030° 22,33' W	5739,0					X	
1036-3	22408-03	19.08.2017	10:52	11° 52,81' N	030° 22,16' W	5694,1					X	
1037-1	NA	19.08.2017	19:34	11° 47,55' N	028° 59,76' W	5734,9	X					
1038-1	22409-01	20.08.2017	10:01	11° 41,26' N	026° 39,34' W	5488,2					X	
1038-2	22409-02	20.08.2017	11:04	11° 41,25' N	026° 39,56' W	5743,6					X	
1038-3	22409-03	20.08.2017	11:27	11° 41,26' N	026° 39,70' W	5488,2					X	
1039-1	NA	21.08.2017	11:28	11° 30,74' N	022° 41,72' W	5065,4				R		
1040-1	NA	21.08.2017	18:50	11° 27,57' N	022° 50,05' W	5349,2				R		
1041-1	22410-01	21.08.2017	19:48	11° 26,89' N	022° 49,64' W	5094,1		X				
1042-1	22410-02	21.08.2017	21:11	11° 26,58' N	022° 49,38' W	5094,4					X	
1042-2	22410-03	21.08.2017	22:20	11° 26,20' N	022° 49,05' W	5094,1					X	
1042-3	22410-04	21.08.2017	22:36	11° 26,14' N	022° 49,00' W	5094,7					X	
1043-1	NA	22.08.2017	09:21	11° 25,05' N	022° 56,01' W	5111,0				R		
1044-1	NA	22.08.2017	14:53	11° 23,39' N	022° 57,22' W	5112,6			D			
1045-1	22411-01	22.08.2017	15:49	11° 23,14' N	022° 57,05' W	5110,5					X	
1046-1	22411-02	22.08.2017	16:18	11° 22,57' N	022° 57,31' W	5109,5					X	
1047-1	22411-03	22.08.2017	16:49	11° 22,17’ N	022° 57,54’ W	5108,6					X	
1048-1	22411-04	22.08.2017	17:18	11° 21,78' N	022° 57,63' W	5109,2					X	
1049-1	22411-05	22.08.2017	17:52	11° 21,26' N	022° 57,47' W	5114,5					X	
1050-1	22411-06	22.08.2017	18:15	11° 20,76' N	022° 57,58' W	5111,7					X	
1051-1	22411-07	22.08.2017	18:58	11° 20,49’ N	022° 57,72’ W	5113,5					X	
1052-1	22411-08	22.08.2017	19:33	11° 20,44' N	022° 59,32' W	5116,5					X	
1053-1	22411-09	22.08.2017	20:07	11° 20,62’ N	022° 59,19’ W	5117,7					X	
1054-1	22411-10	22.08.2017	20:38	11° 21,84' N	022° 59,82' W	5116,7					X	
1055-1	22411-11	22.08.2017	21:13	11° 22,18' N	022° 59,80' W	5117,3					X	
1056-1	22411-12	22.08.2017	21:57	11° 22,41' N	022° 58,43' W	5114,5					X	
1057-1	22411-13	22.08.2017	22:42	11° 22,67' N	022° 58,90' W	5117,5					X	
1058-1	22411-14	22.08.2017	23:13	11° 23,16' N	022° 59,38' W	5118,5					X	
1059-1	22411-15	22.08.2017	23:55	11° 23,93’ N	022° 59,65’ W	5119,3					X	
1060-1	22411-16	23.08.2017	00:37	11° 24,15’ N	022° 58,01’ W	5115,5					X	
1061-1	22411-17	23.08.2017	01:11	11° 24,58’ N	022° 58,34’ W	5118,8					X	
1062-1	22411-18	23.08.2017	01:43	11° 25,22' N	022° 58,36' W	5119,0					X	
1063-1	22411-19	23.08.2017	02:18	11° 24,77’ N	022° 58,57’ W	5117,1					X	
1064-1	22411-20	23.08.2017	02:45	11° 24,71’ N	022° 59,04’ W	5118,4					X	
1065-1	22411-21	23.08.2017	03:32	11° 25,60' N	022° 59,30' W	5116,9					X	
1066-1	22411-22	23.08.2017	03:59	11° 25,60’ N	022° 59,73’ W	5117,1					X	
1067-1	22411-23	23.08.2017	04:32	11° 26,00’ N	022° 59,55’ W	5115,9					X	
1068-1	22411-24	23.08.2017	05:04	11° 26,39’ N	022° 58,90’ W	5115,9					X	
1069-1	22411-25	23.08.2017	05:34	11° 26,70’ N	022° 58,56’ W	5115,4					X	
1070-1	22411-26	23.08.2017	06:01	11° 26,64' N	022° 58,55' W	5115,1					X	
1071-1	22411-27	23.08.2017	06:42	11° 26,38' N	022° 57,72' W	5115,1					X	
1072-1	22411-28	23.08.2017	07:06	11° 26,03' N	022° 57,53' W	5119,0					X	
1073-1	22411-29	23.08.2017	07:43	11° 25,95’ N	022° 56,75’ W	5118,5					X	
1074-1	22411-30	23.08.2017	08:09	11° 25,91' N	022° 56,49' W	5118,7					X	
1075-1	22411-31	23.08.2017	08:39	11° 26,17' N	022° 56,34' W	5120,1					X	
1076-1	22411-32	23.08.2017	09:06	11° 26,24' N	022° 55,56' W	5121,1					X	
1077-1	22411-33	23.08.2017	09:39	11° 26,66’ N	022° 55,58’ W	5120,8					X	
1078-1	22411-34	23.08.2017	10:07	11° 27,32’ N	022° 55,47’ W	5118,1					X	
1079-1	22411-35	23.08.2017	10:49	11° 26,96’ N	022° 54,26’ W	5111,6					X	
1080-1	22411-36	23.08.2017	11:22	11° 27,09’ N	022° 53,52’ W	5108,4					X	
1081-1	22411-37	23.08.2017	11:52	11° 26,99’ N	022° 53,60’ W	5108,1					X	
1082-1	22411-38	23.08.2017	12:28	11° 25,84’ N	022° 54,57’ W	5091,4					X	
1083-1	22411-39	23.08.2017	13:00	11° 25,65' N	022° 54,71' W	5054,4					X	
1084-1	22411-40	23.08.2017	13:32	11° 25,55’ N	022° 55,35’ W	5106,7					X	
1085-1	22411-41	23.08.2017	14:07	11° 25,64' N	022° 55,75' W	5113,7					X	
1086-1	22411-42	23.08.2017	14:35	11° 25,04' N	022° 55,46' W	5105,8					X	
1087-1	22411-43	23.08.2017	15:22	11° 24,69' N	022° 54,19' W	5074,7					X	
1088-1	22411-44	23.08.2017	15:46	11° 24,78’ N	022° 54,04’ W	5079,2					X	
1089-1	22411-45	23.08.2017	16:23	11° 23,60' N	022° 53,21' W	5107,7					X	
1090-1	22411-46	23.08.2017	16:44	11° 23,64' N	022° 53,44' W	5107,4					X	
1091-1	NA	23.08.2017	18:54	11° 29,08' N	022° 40,01' W	5055,5				D		
1092-1	NA	24.08.2017	07:00	11° 27,92' N	022° 55,61' W	5110,9				D		
1093-1	NA	24.08.2017	15:29	11° 27,85' N	022° 51,53' W	5097,9			R			

1094-1	NA	24.08.2017	16:03	11° 27,84' N	022° 51,37' W	5099,5	X					
1095-1	22412-01	25.08.2017	09:32	14° 06,70' N	023° 44,43' W	4252,8					X	
1095-2	22412-02	25.08.2017	10:44	14° 06,41' N	023° 44,50' W	4257,4					X	
1095-3	22412-03	25.08.2017	11:07	14° 06,28' N	023° 44,61' W	4258,1					X	
1096-1	22413-01	27.08.2017	10:31	19° 31,20' N	022° 35,44' W	3851,2					X	
1096-2	22413-01	27.08.2017	11:41	19° 31,40' N	022° 35,36' W	3854,6					X	
1096-3	22413-01	27.08.2017	12:05	19° 31,46' N	022° 35,36' W	3854,6					X	
1097-1	NA	27.08.2017	21:59	20° 39,64' N	021° 32,09' W	4136,0	X					
1098-1	22414-01	28.08.2017	04:02	21° 14,18' N	021° 02,00' W	4227,1						X
1098-2	22414-02	28.08.2017	04:23	21° 14,23' N	021° 02,04' W	4227,2						X
1098-3	22414-03	28.08.2017	04:56	21° 14,33' N	021° 02,14' W	4229,7						X
1098-4	22414-04	28.08.2017	05:19	21° 14,40' N	021° 02,20' W	4230,5						X
1098-5	22414-05	28.08.2017	05:43	21° 14,48' N	021° 02,27' W	4231,3						X
1099-1	22414-06	28.08.2017	07:12	21° 16,40' N	020° 59,91' W	4215,5				R		
1100-1	22414-07	28.08.2017	13:50	21° 12,35' N	020° 53,26' W	NA				R		
1101-2	NA	28.08.2017	17:17	21° 14,98' N	020° 50,69' W	4161,7			D			
1102-1	NA	28.08.2017	18:07	21° 15,95' N	020° 50,14' W	4172,9			D			
1103-1	22414-08	28.08.2017	19:15	21° 16,87' N	020° 49,61' W	4177,6						X
1104-1	22414-09	28.08.2017	20:26	21° 16,89' N	020° 49,60' W	4175,0					X	
1104-2	22414-10	28.08.2017	21:27	21° 17,02' N	020° 49,37' W	4174,4					X	
1104-3	22414-11	28.08.2017	21:51	21° 17,04' N	020° 49,30' W	4172,5					X	
1105-1	22414-13	28.08.2017	22:44	21° 17,02' N	020° 49,26' W	4172,8						X
1105-2	22414-14	29.08.2017	00:08	21° 17,23' N	020° 49,37' W	4173,4						X
1105-3	22414-15	29.08.2017	04:35	21° 18,02' N	020° 50,13' W	4178,2						X
1106-1	NA	29.08.2017	07:00	21° 14,61' N	021° 01,69' W	4226,9				D		
1107-1	NA	29.08.2017	14:30	21° 14,05' N	020° 52,06' W	4161,2				D		
1108-1	22415-02	29.08.2017	17:36	21° 15,59' N	020° 50,53' W	4166,0						X
1109-1	NA	29.08.2017	18:45	21° 16,04' N	020° 50,51' W	4168,2			R			
1110-1	NA	29.08.2017	19:54	21° 17,17' N	020° 49,57' W	4176,1			R			
1111-1	22415-03	29.08.2017	20:39	21° 17,33' N	020° 49,47' W	4174,1						X
1112-1	22415-05	29.08.2017	22:00	21° 17,38' N	020° 49,48' W	4174,8					X	
1113-1	NA	30.08.2017	12:07	20° 51,53' N	018° 45,74' W	NA				R		
1114-1	22416-02	30.08.2017	14:35	20° 50,66' N	018° 47,59' W	2800,4						X
1115-1	NA	30.08.2017	15:49	20° 50,66' N	018° 47,60' W	2798,0			D			
1116-1	22416-03	30.08.2017	16:29	20° 50,61' N	018° 47,79' W	2807,4					X	
1117-1	22416-04	30.08.2017	17:13	20° 50,70' N	018° 47,96' W	2818,9		X				
1118-1	22416-05	30.08.2017	18:34	20° 50,71' N	018° 47,96' W	2816,3						X
1118-2	22416-06	30.08.2017	19:53	20° 50,78' N	018° 48,08' W	2826,5						X
1118-3	22416-07	30.08.2017	21:11	20° 50,96' N	018° 48,42' W	2840,2						X
1118-4	22416-08	31.08.2017	07:44	20° 51,85' N	018° 50,63' W	2939,1						X
1119-1	22417-01	31.08.2017	09:35	20° 52,15' N	018° 56,26' W	3088,8					X	
1119-2	22417-02	31.08.2017	10:36	20° 52,18' N	018° 56,31' W	3088,2					X	
1119-3	22417-03	31.08.2017	10:57	20° 52,18' N	018° 56,32' W	3088,5					X	
1120-1	22418-01	31.08.2017	11:44	20° 52,19' N	018° 56,35' W	3091,1						X
1121-1	22418-02	31.08.2017	14:36	20° 42,02' N	018° 45,46' W	2788,8						X
1122-1	NA	31.08.2017	17:13	20° 52,77' N	018° 47,01' W	2818,3			D			
1123-1	NA	31.08.2017	17:55	20° 52,93' N	018° 46,94' W	2817,3			R			
1124-1	22419-02	31.08.2017	18:33	20° 53,19' N	018° 46,99' W	2826,7						X
1125-1	22418-03	31.08.2017	20:47	21° 02,13' N	018° 45,45' W	2849,6						X
1126-1	22418-04	31.08.2017	21:53	21° 02,18' N	018° 45,58' W	2856,6					X	
1127-1	22418-05	01.09.2017	00:17	20° 52,11' N	018° 34,67' W	2346,8						X
1128-1	22418-06	01.09.2017	02:39	20° 49,93' N	018° 44,98' W	2699,1						X
1128-2	22418-07	01.09.2017	03:55	20° 49,92' N	018° 44,98' W	2700,4						X
1128-3	22418-08	01.09.2017	07:55	20° 49,36' N	018° 45,21' W	2702,8						X
1129-1	NA	01.09.2017	09:08	20° 49,38' N	018° 45,27' W	2704,0				D		
1130-1	22420-02	01.09.2017	11:14	20° 50,47' N	018° 44,67' W	2694,6						X
1131-1	22419-03	01.09.2017	13:04	20° 53,36' N	018° 44,33' W	2746,7						X
1131-2	22419-04	01.09.2017	14:21	20° 53,36' N	018° 44,33' W	2748,3						X
1131-3	22419-05	01.09.2017	16:48	20° 53,36' N	018° 44,33' W	2747,9						X
1132-2	NA	01.09.2017	18:04	20° 53,50' N	018° 43,21' W	2717,8			R			
1133-1	NA	02.09.2017	10:00	22° 59,11' N	017° 37,67' W	1544,6	X					
1134-1	22421-01	03.09.2017	10:23	24° 43,73' N	016° 34,36' W	864,9					X	
1134-2	22421-02	03.09.2017	11:26	24° 43,73' N	016° 34,36' W	865,3					X	
1134-3	22421-03	03.09.2017	11:54	24° 43,73' N	016° 34,36' W	865,0					X	

8 Data availability and sample storage

All hydrographic data from the CTD and multinet casts are publicly available on PANGAEA. Thermosalinograph and ADCP data monitoring during the cruise are available from MARUM upon request. Samples of planktonic foraminifera from the net hauls are stored and curated at MARUM. Dust from buoys and on-board collection and sediment trap samples from M3 and M1 are stored and curated at NIOZ. Sediment trap samples from CB and CBi and drifting net samples are stored and curated at MARUM. Phytoplankton samples are stored and curated at CEREGE. Unused residues of all physical samples will be made available upon request 3 years after the cruise. Water chemistry samples are curated at MARUM and NIOZ; their analyses are destructive and residues will not be available.

Table 8.1. Overview of data availability

Type	**Database**	**Available**	**Free Access**	**Contact**
CTD	PANGAEA	July 2018	July 2019	msiccha@marum.de
ADCP	MARUM	July 2018	July 2019	msiccha@marum.de
Water chemistry		with publication	with publication	mkucera@marum.de
Biooptical profiles		with publication	with publication	miversen@marum.de
Dust data		with publication	with publication	jan-berend.stuut@nioz.nl
Faunal data from plankton		with publication	with publication	mkucera@marum.de
Sediment trap M3		with publication	with publication	Geert-Jan.Brummer@nioz.nl
Sediment trap M1		with publication	with publication	mkucera@marum.de
Sediment traps CB & CBi		with publication	with publication	gfischer@marum.de

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11 Appendix

Table 11.1: Plankton pump sample list

Sample-ID	start date-time	end date-time	Duration [hh:mm]	Longitude [decimal]	Latitude [decimal]	Water filtered [m³]
PP1	12.8.17 18:28	13.8.17 9:27	14h:59m	-29.965	15.516	36.68
PP2	13.8.17 9:33	13.8.17 20:51	11h:17m	-32.506	14.791	27.66
PP3	13.8.17 20:59	14.8.17 8:22	11h:23m	-34.282	14.275	27.87
PP4	14.8.17 8:29	14.8.17 20:42	12h:13m	-36.068	13.759	29.91
PP5a, PP5b	14.8.17 20:47	15.8.17 8:29	11h:42m	-37.713	13.284	28.64
PP6	15.8.17 8:36	15.8.17 14:14	5h:38m	-38.869	12.346	13.79
PP7	15.8.17 14:17	15.8.17 17:17	3h:0m	-38.66	12.392	7.34
PP8	15.8.17 17:20	15.8.17 20:16	2h:56m	-38.667	12.433	7.18
PP9	15.8.17 20:16	15.8.17 23:17	3h:0m	-38.607	12.46	7.38
PP10	15.8.17 23:18	16.8.17 2:17	2h:58m	-38.606	12.536	7.30
PP11	16.8.17 2:19	16.8.17 5:17	2h:57m	-38.677	12.528	7.26
PP12	16.8.17 5:18	16.8.17 8:17	2h:58m	-38.59	12.54	7.30
PP13	16.8.17 8:19	16.8.17 11:17	2h:57m	-38.52	12.522	7.26
PP14	16.8.17 11:20	16.8.17 14:17	2h:57m	-38.549	12.492	7.22
PP15	16.8.17 14:20	16.8.17 17:18	2h:58m	-38.59	12.434	7.26
PP16	16.8.17 17:21	16.8.17 20:17	2h:55m	-38.614	12.383	7.18
PP17	16.8.17 20:19	17.8.17 12:40	16h:21m	-38.649	12.386	40.02
PP18	17.8.17 12:42	18.8.17 20:40	31h:57m	-36.803	12.289	78.25
PP19	18.8.17 20:42	19.8.17 8:35	11h:52m	-32.497	12.015	29.09
PP20	19.8.17 8:39	19.8.17 20:41	12h:1m	-30.509	11.89	29.46
PP21	19.8.17 20:43	20.8.17 9:10	12h:27m	-28.808	11.787	30.48
PP22	20.8.17 9:13	20.8.17 20:54	11h:41m	-26.762	11.694	28.60
PP23	20.8.17 20:58	21.8.17 9:16	12h:17m	-25.255	11.626	30.11
PP24	21.8.17 9:18	21.8.17 21:19	12h:1m	-23.076	11.527	29.42
PP25	21.8.17 21:21	22.8.17 13:59	16h:38m	-22.822	11.442	40.72
PP26	22.8.17 14:02	22.8.17 16:59	2h:57m	-22.951	11.395	7.22
PP27	22.8.17 17:00	22.8.17 19:59	2h:58m	-22.959	11.369	7.30
PP28	22.8.17 20:00	22.8.17 23:20	3h:19m	-22.989	11.342	8.16
PP29	22.8.17 23:21	23.8.17 1:58	2h:36m	-22.989	11.386	6.41
PP30	23.8.17 2:00	23.8.17 4:59	2h:58m	-22.973	11.42	7.30
PP31	23.8.17 5:01	23.8.17 7:59	2h:58m	-22.982	11.44	7.26
PP32	23.8.17 8:01	23.8.17 14:00	5h:59m	-22.944	11.433	14.65
PP33	23.8.17 14:02	23.8.17 18:58	4h:56m	-22.93	11.427	12.08
PP34	23.8.17 17:00	24.8.17 8:50	15h:49m	-22.89	11.3983	38.76
PP35	24.8.17 9:02	24.8.17 20:57	11h:55m	-22.933	11.447	29.17
PP36	24.8.17 20:59	25.8.17 9:18	12h:18m	-23.122	12.235	30.15
PP37	25.8.17 9:23	25.8.17 16:25	7h:2m	-23.737	14.109	17.22
PP38	26.8.17 15:52	27.8.17 9:18	17h:25m	-24.702	17.275	44.58
PP39	27.8.17 9:22	27.8.17 20:59	11h:36m	-22.704	19.399	29.71
PP40	27.8.17 21:02	27.8.17 9:02	12h:0m	-21.629	20.556	30.69
PP41	28.8.17 9:13	28.8.17 20:58	11h:45m	-20.985	21.286	30.05
PP42	28.8.17 21:00	29.8.17 9:24	12h:24m	-20.824	21.283	31.71
PP43	29.8.17 9:29	29.8.17 20:26	10h:57m	-21.01	21.254	28.00
PP44	29.8.17 20:31	30.8.17 9:03	12h:31m	-20.824	21.289	32.05
PP45	30.8.17 9:14	30.8.17 21:02	11h:47m	-19.193	20.965	30.17
PP46	30.8.17 21:07	31.8.17 9:02	11h:54m	-18.807	20.849	30.47

PP47	31.8.17 9:07	31.8.17 21:44	12h:36m	-18.888	20.871	32.26
PP48	31.8.17 21:50	1.9.17 9:15	11h:25m	-18.76	21.036	29.19
PP49	1.9.17 9:19	1.9.17 20:58	11h:39m	-18.753	20.826	29.79
PP50	1.9.17 21:03	2.9.17 9:17	12h:14m	-18.55	21.219	31.28
PP51	2.9.17 9:23	2.9.17 21:47	12h:23m	-17.667	22.912	31.71
PP52	2.9.17 21:50	3.9.17 10:04	12h:14m	-17.037	23.847	31.28
PP53	3.9.17 10:08	3.9.17 21:00	10h:51m	-16.576	24.718	27.79
PP54	3.9.17 21:03	4.9.17 8:04	11h:0m	-16.244	25.535	28.17

Table 11.2: Summary of phytoplankton samples taken during M140.

Date (UTC)	**Station Label**	**Latitude**	**Longitude**	**Water depth (m)**	**Filtered Volume (ml)**
Net Niskin bottles					
12.08.2017	GeoB22402-2	15°52,24'N	28°44.71'W	20	450
12.08.2017	GeoB22402-2	15°52,24'N	28°44.71'W	60	1100
12.08.2017	GeoB22402-3	15°52,24'N	28°44.71'W	40	1325
13.08.2017	GeoB22403-2	14°47,39'N	32°31.44'W	20	945
13.08.2017	GeoB22403-2	14°47,39'N	32°31.44'W	60	1300
13.08.2017	GeoB22403-3	14°47,39'N	32°31.44'W	80	1620
14.08.2017	GeoB22404-2	13°43,550'N	36°13.398'W	20	780
14.08.2017	GeoB22404-2	13°43,550'N	36°13.398'W	60	1300
14.08.2017	GeoB22404-3	13°43,550'N	36°13.398'W	80	1650
16.08.2017	SVBT9363	12°23.11'N	38°34,68'W	35	880
16.08.2017	FUSH5410	12°23.30'N	38°36.35'W	50	880
16.08.2017	FUSH5410	12°23.30'N	38°36.35'W	84	1150
17.08.2017	GeoB22406-2	12°17.70'N	36°56.76'W	20	750
17.08.2017	GeoB22406-2	12°17.70'N	36°56.76'W	60	960
17.08.2017	GeoB22406-3	12°17.70'N	36°56.76'W	80	1330
18.08.2017	GeoB22407-2	12°05.934'N	33°47.580'W	20	530
18.08.2017	GeoB22407-2	12°05.934'N	33°47.580'W	100	945
18.08.2017	GeoB22407-3	12°05.934'N	33°47.580'W	80	1350
19.08.2017	GeoB22408-2	11°52.800'N	30°22.002'W	20	1060
19.08.2017	GeoB22408-2	11°52.800'N	30°22.002'W	80	720
19.08.2017	GeoB22408-2	11°52.800'N	30°22.002'W	100	1260
20.08.2017	GeoB22409-2	11°41.35'N	26°39.80'W	20	630
20.08.2017	GeoB22409-2	11°41.35'N	26°39.80'W	80	520
20.08.2017	GeoB22409-2	11°41.35'N	26°39.80'W	100	1030
25.08.2017	GeoB22412-2	14°06.08'N	23°44.68'W	20	990
25.08.2017	GeoB22412-2	14°06.08'N	23°44.68'W	60	750
25.08.2017	GeoB22412-2	14°06.08'N	23°44.68'W	80	770
27.08.2017	GeoB22413-2	19.51.99'N	22°59.07'W	20	1150
27.08.2017	GeoB22413-2	19.51.99'N	22°59.07'W	60	625
27.08.2017	GeoB22413-3	19.51.99'N	22°59.07'W	40	1500
28.08.2017	GeoB22414-2	21°17.05'N	20°49.27'W	20	550
28.08.2017	GeoB22414-2	21°17.05'N	20°49.27'W	60	850
28.08.2017	GeoB22414-3	21°17.05'N	20°49.27'W	40	1350
03.09.2017	GeoB24421-2	24°43.74'N	16°34.36'W	20	980
03.09.2017	GeoB24421-2	24°43.74'N	16°34.36'W	40	500
03.09.2017	GeoB24421-2	24°43.74'N	16°34.36'W	60	625

03.09.2017	GeoB24421-2	24°43.74'N	16°34.36'W	80	880
CTD Niskin bottles					
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	400	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	160	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	100	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	60	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	50	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	40	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	30	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	20	3000
21.08.2017	GeoB22410-1	11°26.20'N	22°49.05'W	10	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	10	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	20	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	40	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	60	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	80	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	100	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	240	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	330	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	500	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	900	3000
30.08.2017	GeoB22416-4	20°50.70'N	18°47.96'W	1250	3000

Table 11.3: Summary of DriftCam deployments during M140.

Profile No.	Station)	Ship Sta.	Date (D/M/Y)	Start Time (H:M:S)	Latitude (°)	Longitude (°)	Water Depth (m)	Depl. Depth (m)
WetTest-01	GeoB22414-1	1098-1	28/08/17	04:00:20	21°14.179'N	021°01.996'W	4226	50
WetTest-02	GeoB22414-2	1098-2	28/08/17	04:21:50	21°14.179'N	021°01.996'W	4226	50
WetTest-03	GeoB22414-3	1098-3	28/08/17	04:56:17	21°14.179'N	021°01.996'W	4226	50
WetTest-04	GeoB22414-4	1098-4	28/08/17	05:19:20	21°14.179'N	021°01.996'W	4226	50
Profile-01	GeoB22414-5	1098-5	28/08/17	05:43:44	21°14.179'N	021°01.996'W	4226	500
Profile-02	GeoB22414-8	1101	28/08/17	19:15:03	21°16.873'N	020°49.607'W	4176	500
Profile-03	GeoB22414-12	1104	28/08/17	22:44:27	21°17.027'N	020°49.249'W	4173	500
Stationary-01	GeoB22414-13	1105-1	29/08/17	00:07:58	21°17.241'N	020°49.393'W	4173	100
Profile-04	GeoB22414-14	1105-2	29/08/17	04:35:15	21°18.041'N	020°50.142'W	4178	500
Profile-05	GeoB22415-2	1108	29/08/17	17:35:30	21°15.578'N	020°50.527'W	4166	500
Profile-06	GeoB22415-3	1111	29/08/17	20:39:33	21°17.340'N	020°49.47'W	4174	500
Profile-07	GeoB22416-2	1114	30/08/17	14:35:25	21°50.655'N	018°47.595'W	2800	500
Profile-08	GeoB22416-5	1118-1	30/08/17	18:33:39	20°50.713'N	018°47.959'W	2818	500
Profile-09	GeoB22416-6	1118-2	30/08/17	19:53:16	20°50.790'N	018°48.100'W	2825	500
Stationary-02	GeoB22416-7	1118-3	30/08/17	21:10:48	20°50.996'N	018°48.424'W	2841	100
Profile-10	GeoB22416-8	1118-4	31/08/17	07:42:50	20°51.846'N	018°50.632'W	2940	500
Profile-11	GeoB22418_1	1120	31/08/17	11:44:31	20°52.195'N	018°56.349'W	3090	500
Profile-12	GeoB22418-2	1121	31/08/17	14:36:05	20°42.016'N	018°45.462'W	2791	500
Profile-13	GeoB22419-2	1124	31/08/17	18:33:17	20°53.190'N	018°46.992'W	2829	500
Profile-14	GeoB22418-3	1125	31/08/17	20:46:55	21°02.126'N	018°45.451'W	2850	500
Profile-15	GeoB22418-5	1127	01/09/17	0:16:58	20°52.114'N	018°34.670'W	2346	500
Profile-16	GeoB22418-6	1128-1	01/09/17	2:39:04	20°49.925'N	018°44.982'W	2700	500
Stationary-03	GeoB22418-7	1128-2	01/09/17	3:55:18	20°49.925'N	018°44.982'W	2699	100

Profile-17	GeoB22418-8	1128-3	01/09/17	7:54:44	20°49.373'N	018°45.228'W	2702	500
Profile-18	GeoB22420-2	1130	01/09/17	11:14:17	20°50.467'N	018°44.673'W	2694	500
Profile-19	GeoB22419-3	1131-1	01/09/17	13:04:23	20°53.357'N	018°44.334'W	2748	500
Stationary-04	GeoB22419-4	1131-2	01/09/17	14:20:35	20°53.358'N	018°44.334'W	2747	100
Profile-20	GeoB22419-5	1131-3	01/09/17	16:49:14	20°53.358'N	018°44.335'W	2747	500

Table 11.4: Summary of pH and alkalinity measurement during M140

Date [UTC]	Station	Depth [m]	ph []	pH stdev	Alkalinity	Alk stdev
11.08.2017	GeoB22401-1	250	7.73	0.09	2.47	0.07
11.08.2017	GeoB22401-1	200	7.77	0.01	2.45	0.01
11.08.2017	GeoB22401-1	150	7.85	0.02	2.46	0.01
11.08.2017	GeoB22401-1	100	7.90	0.02	2.47	0.00
11.08.2017	GeoB22401-1	50	8.11	0.02	2.48	0.02
12.08.2017	GeoB22402-1	700	8.00	0.01	2.49	0.00
12.08.2017	GeoB22402-1	500	7.71	0.02	2.39	0.00
12.08.2017	GeoB22402-1	300	7.74	0.01	2.40	0.02
12.08.2017	GeoB22402-1	200	7.73	0.01	2.49	0.12
12.08.2017	GeoB22402-1	100	7.84	0.00	2.43	0.02
12.08.2017	GeoB22402-2	100	8.15	0.01	2.47	0.02
12.08.2017	GeoB22402-2	80	7.99	0.01	2.47	0.03
12.08.2017	GeoB22402-2	60	8.05	0.00	2.49	0.02
12.08.2017	GeoB22402-2	40	8.08	0.01	2.50	0.01
12.08.2017	GeoB22402-2	20	8.11	0.01	2.47	0.01
12.08.2017	GeoB22402-3	150	7.71	0.02	2.42	0.01
13.08.2017	GeoB22403-1	700	7.93	0.02	2.45	0.01
13.08.2017	GeoB22403-1	500	7.69	0.02	2.39	0.01
13.08.2017	GeoB22403-1	300	7.69	0.02	2.39	0.03
13.08.2017	GeoB22403-1	200	7.73	0.01	2.40	0.02
13.08.2017	GeoB22403-1	100	7.78	0.02	2.44	0.01
13.08.2017	GeoB22403-2	100	8.18	0.01	2.46	0.02
13.08.2017	GeoB22403-2	80	7.94	0.00	2.48	0.00
13.08.2017	GeoB22403-2	60	7.99	0.01	2.49	0.01
13.08.2017	GeoB22403-2	40	8.12	0.00	2.46	0.03
13.08.2017	GeoB22403-2	20	8.16	0.00	2.45	0.03
13.08.2017	GeoB22403-3	150	7.74	0.01	2.41	0.01
14.08.2017	GeoB22404-1	700	7.92	0.05	2.49	0.01
14.08.2017	GeoB22404-1	500	7.65	0.03	2.43	0.03
14.08.2017	GeoB22404-1	300	7.65	0.02	2.41	0.04
14.08.2017	GeoB22404-1	200	7.68	0.02	2.43	0.02
14.08.2017	GeoB22404-1	100	7.74	0.03	2.45	0.05
14.08.2017	GeoB22404-2	100	8.17	0.02	2.52	0.04
14.08.2017	GeoB22404-2	80	7.94	0.03	2.49	0.00
14.08.2017	GeoB22404-2	60	8.04	0.02	2.52	0.04
14.08.2017	GeoB22404-2	40	8.08	0.03	2.52	0.03
14.08.2017	GeoB22404-2	20	8.15	0.02	2.52	0.04
14.08.2017	GeoB22404-3	150	7.69	0.02	2.44	0.03
15.08.2017	DVRS6536	140	7.88	0.01	2.43	0.03
15.08.2017	DVRS6536	107	7.92	0.01	2.46	0.00
15.08.2017	DVRS6536	75	8.16	0.00	2.42	0.06
15.08.2017	DVRS6536	60	8.18	0.01	2.46	0.05

15.08.2017	DVRS6536	31	8.20	0.00	2.51	0.00
15.08.2017	DEAY9146	285	7.75	0.01	2.41	0.01
15.08.2017	DEAY9146	221	7.76	0.01	2.42	0.00
15.08.2017	DEAY9146	162	7.82	0.01	2.43	0.00
15.08.2017	DEAY9146	93	7.90	0.03	2.47	0.00
15.08.2017	DEAY9146	41	8.17	0.03	2.51	0.03
15.08.2017	DPHE0358	97	7.98	0.01	2.53	0.02
15.08.2017	DPHE0358	78	8.08	0.06	2.60	0.01
15.08.2017	DPHE0358	53	8.16	0.02	2.65	0.03
15.08.2017	DPHE0358	36	8.17	0.01	2.68	0.04
15.08.2017	DPHE0358	17	8.18	0.02	2.68	0.03
15.08.2017	BXDV7815	262	7.72	0.02	2.60	0.03
15.08.2017	BXDV7815	193	7.78	0.02	2.61	0.05
15.08.2017	BXDV7815	125	7.85	0.02	2.56	0.06
15.08.2017	BXDV7815	83	8.02	0.02	2.54	0.04
15.08.2017	BXDV7815	31	8.19	0.01	2.52	0.04
16.08.2017	JMGX4246	251	7.75	0.01	2.38	0.02
16.08.2017	JMGX4246	218	7.79	0.01	2.36	0.01
16.08.2017	JMGX4246	162	7.83	0.01	2.38	0.01
16.08.2017	JMGX4246	124	7.93	0.01	2.40	0.03
16.08.2017	JMGX4246	67	8.17	0.01	2.61	0.30
16.08.2017	KFVP3225	129	7.91	0.01	2.39	0.03
16.08.2017	KFVP3225	112	7.95	0.01	2.42	0.06
16.08.2017	KFVP3225	78	8.10	0.00	2.45	0.01
16.08.2017	KFVP3225	56	8.16	0.01	2.40	0.06
16.08.2017	KFVP3225	29	8.21	0.01	2.44	0.02
16.08.2017	VWXU0012	124	7.88	0.03	2.46	0.04
16.08.2017	VWXU0012	101	7.99	0.02	2.48	0.01
16.08.2017	VWXU0012	71	8.16	0.02	2.49	0.04
16.08.2017	VWXU0012	49	8.18	0.02	2.48	0.01
16.08.2017	VWXU0012	22	8.18	0.01	2.47	0.02
16.08.2017	BLJO8338	275	7.74	0.02	2.40	0.03
16.08.2017	BLJO8338	209	7.77	0.01	2.41	0.03
16.08.2017	BLJO8338	173	7.78	0.01	2.43	0.04
16.08.2017	BLJO8338	119	7.85	0.01	2.45	0.02
16.08.2017	BLJO8338	67	8.15	0.02	2.48	0.02
16.08.2017	SVBT9363	225	7.72	0.03	2.40	0.04
16.08.2017	SVBT9363	181	7.77	0.01	2.39	0.01
16.08.2017	SVBT9363	141	7.84	0.00	2.43	0.03
16.08.2017	SVBT9363	98	7.95	0.01	2.44	0.02
16.08.2017	SVBT9363	35	8.19	0.01	2.43	0.03
16.08.2017	FUSH5410	131	7.85	0.02	2.43	0.00
16.08.2017	FUSH5410	103	7.95	0.02	2.46	0.00
16.08.2017	FUSH5410	84	8.03	0.01	2.46	0.00
16.08.2017	FUSH5410	50	8.13	0.01	2.46	0.01
16.08.2017	FUSH5410	34	8.15	0.01	2.47	0.00
17.08.2017	GeoB22406-1	700	7.63	0.02	2.36	0.01
17.08.2017	GeoB22406-1	500	7.66	0.01	2.38	0.02
17.08.2017	GeoB22406-1	300	7.68	0.01	2.39	0.02
17.08.2017	GeoB22406-1	200	7.68	0.01	2.37	0.02

17.08.2017	GeoB22406-1	100	7.78	0.01	2.40	0.01
17.08.2017	GeoB22406-2	100	7.81	0.02	2.41	0.00
17.08.2017	GeoB22406-2	80	7.94	0.01	2.45	0.00
17.08.2017	GeoB22406-2	60	8.07	0.02	2.47	0.01
17.08.2017	GeoB22406-2	40	8.14	0.02	2.47	0.01
17.08.2017	GeoB22406-2	20	8.17	0.01	2.47	0.01
17.08.2017	GeoB22406-3	150	7.71	0.02	2.39	0.01
18.08.2017	GeoB22407-1	700	7.64	0.00	2.33	0.05
18.08.2017	GeoB22407-1	500	7.69	0.02	2.36	0.01
18.08.2017	GeoB22407-1	300	7.71	0.03	2.36	0.03
18.08.2017	GeoB22407-1	200	failed	failed	failed	failed
18.08.2017	GeoB22407-1	100	7.78	0.01	2.35	0.04
18.08.2017	GeoB22407-2	100	7.89	0.01	2.36	0.04
18.08.2017	GeoB22407-2	80	7.96	0.01	2.40	0.03
18.08.2017	GeoB22407-2	60	8.07	0.00	2.43	0.03
18.08.2017	GeoB22407-2	40	8.16	0.01	2.46	0.02
18.08.2017	GeoB22407-2	20	8.19	0.01	2.44	0.01
18.08.2017	GeoB22407-3	150	7.72	0.02	2.39	0.01
19.08.2017	GeoB22408-1	700	7.69	0.01	2.37	0.00
19.08.2017	GeoB22408-1	500	7.67	0.01	2.38	0.00
19.08.2017	GeoB22408-1	300	7.71	0.01	2.39	0.00
19.08.2017	GeoB22408-1	200	7.75	0.01	2.39	0.00
19.08.2017	GeoB22408-1	100	7.81	0.01	2.41	0.00
19.08.2017	GeoB22408-2	100	7.84	0.00	2.42	0.01
19.08.2017	GeoB22408-2	80	7.84	0.01	2.42	0.01
19.08.2017	GeoB22408-2	60	7.94	0.01	2.44	0.00
19.08.2017	GeoB22408-2	40	8.15	0.01	2.45	0.02
19.08.2017	GeoB22408-2	20	8.18	0.02	2.42	0.00
19.08.2017	GeoB22408-3	150	7.75	0.01	2.39	0.04
20.08.2017	GeoB22409-1	700	7.68	0.01	2.39	0.01
20.08.2017	GeoB22409-1	500	7.65	0.01	2.37	0.05
20.08.2017	GeoB22409-1	300	7.69	0.01	2.36	0.03
20.08.2017	GeoB22409-1	200	7.75	0.01	2.40	0.03
20.08.2017	GeoB22409-1	100	7.80	0.01	2.39	0.01
20.08.2017	GeoB22409-2	100	7.80	0.01	2.39	0.03
20.08.2017	GeoB22409-2	80	7.83	0.01	2.38	0.03
20.08.2017	GeoB22409-2	60	7.87	0.01	2.44	0.00
20.08.2017	GeoB22409-2	40	8.13	0.01	2.46	0.00
20.08.2017	GeoB22409-2	20	8.21	0.01	2.47	0.01
20.08.2017	GeoB22409-3	150	7.74	0.04	2.41	0.01
21.08.2017	GeoB22410-1	1250	7.81	0.01	2.41	0.02
21.08.2017	GeoB22410-1	1000	7.75	0.02	2.41	0.00
21.08.2017	GeoB22410-1	700	7.69	0.01	2.40	0.00
21.08.2017	GeoB22410-1	400	7.69	0.02	2.41	0.01
21.08.2017	GeoB22410-1	300	7.71	0.01	2.40	0.01
21.08.2017	GeoB22410-1	160	7.81	0.01	2.42	0.01
21.08.2017	GeoB22410-1	100	7.80	0.02	2.45	0.03
21.08.2017	GeoB22410-1	60	7.80	0.02	2.46	0.04
21.08.2017	GeoB22410-1	50	7.88	0.01	2.49	0.04
21.08.2017	GeoB22410-1	40	8.06	0.01	2.47	0.01

21.08.2017	GeoB22410-1	30	8.15	0.01	2.47	0.01
21.08.2017	GeoB22410-1	20	8.21	0.02	2.46	0.02
21.08.2017	GeoB22410-1	10	8.22	0.01	2.46	0.01
22.08.2017	Fox	294	7.69	0.02	2.40	0.00
22.08.2017	Fox	232	7.77	0.01	2.40	0.01
22.08.2017	Fox	176	7.81	0.02	2.42	0.01
22.08.2017	Fox	107	7.83	0.02	2.43	0.01
22.08.2017	Fox	56	7.81	0.01	2.43	0.02
22.08.2017	Goose	139	7.80	0.01	2.42	0.01
22.08.2017	Goose	110	7.82	0.01	2.38	0.01
22.08.2017	Goose	76	7.84	0.02	2.40	0.03
22.08.2017	Goose	44	7.89	0.00	2.42	0.03
22.08.2017	Goose	28	8.21	0.00	2.47	0.00
22.08.2017	Shark	226	7.82	0.01	2.40	0.01
22.08.2017	Shark	189	7.87	0.02	2.42	0.01
22.08.2017	Shark	120	7.83	0.03	2.41	0.02
22.08.2017	Shark	89	7.84	0.01	2.43	0.01
22.08.2017	Shark	42	8.04	0.01	2.46	0.01
23.08.2017	Octopus	131	7.84	0.01	2.42	0.00
23.08.2017	Octopus	115	7.86	0.01	2.43	0.00
23.08.2017	Octopus	81	7.83	0.00	2.43	0.01
23.08.2017	Octopus	60	7.85	0.02	2.43	0.00
23.08.2017	Octopus	31	8.20	0.01	2.46	0.00
23.08.2017	Gull	241	7.80	0.01	2.39	0.03
23.08.2017	Gull	178	7.84	0.02	2.42	0.01
23.08.2017	Gull	137	7.85	0.01	2.42	0.01
23.08.2017	Gull	82	7.85	0.01	2.44	0.01
23.08.2017	Gull	40	8.00	0.01	2.46	0.01
23.08.2017	Cat	130	7.84	0.01	2.43	0.01
23.08.2017	Cat	104	7.85	0.01	2.44	0.01
23.08.2017	Cat	81	7.86	0.02	2.44	0.01
23.08.2017	Cat	51	7.97	0.01	2.47	0.01
23.08.2017	Cat	21	8.22	0.01	2.46	0.02
23.08.2017	Pig	221	7.79	0.02	2.42	0.00
23.08.2017	Pig	178	7.85	0.01	2.43	0.00
23.08.2017	Pig	145	7.83	0.00	2.44	0.00
23.08.2017	Pig	114	7.85	0.01	2.43	0.00
23.08.2017	Pig	58	7.84	0.01	2.44	0.01
23.08.2017	Hedgehog	112	7.85	0.02	2.42	0.04
23.08.2017	Hedgehog	94	7.84	0.01	2.45	0.00
23.08.2017	Hedgehog	61	7.85	0.02	2.44	0.00
23.08.2017	Hedgehog	41	8.00	0.01	2.47	0.00
23.08.2017	Hedgehog	24	8.22	0.01	2.47	0.00
25.08.2017	GeoB22412-1	700	7.76	0.01	2.41	0.01
25.08.2017	GeoB22412-1	500	7.75	0.01	2.43	0.01
25.08.2017	GeoB22412-1	300	7.77	0.01	2.44	0.01
25.08.2017	GeoB22412-1	200	7.78	0.01	2.45	0.00
25.08.2017	GeoB22412-1	100	7.84	0.02	2.46	0.01
25.08.2017	GeoB22412-2	100	7.83	0.01	2.46	0.00
25.08.2017	GeoB22412-2	80	7.85	0.01	2.46	0.01

25.08.2017	GeoB22412-2	60	8.14	0.01	2.50	0.01
25.08.2017	GeoB22412-2	40	8.20	0.01	2.51	0.00
25.08.2017	GeoB22412-2	20	8.25	0.01	2.51	0.00
25.08.2017	GeoB22412-3	150	7.83	0.02	2.45	0.02
27.08.2017	GeoB22413-1	700	7.79	0.01	2.41	0.04
27.08.2017	GeoB22413-1	500	7.78	0.01	2.43	0.02
27.08.2017	GeoB22413-1	300	7.80	0.01	2.45	0.04
27.08.2017	GeoB22413-1	200	7.81	0.03	2.44	0.04
27.08.2017	GeoB22413-1	100	7.88	0.01	2.46	0.02
27.08.2017	GeoB22413-2	100	7.91	0.01	2.48	0.02
27.08.2017	GeoB22413-2	80	7.93	0.00	2.49	0.01
27.08.2017	GeoB22413-2	60	8.00	0.01	2.53	0.05
27.08.2017	GeoB22413-2	40	8.21	0.01	2.53	0.03
27.08.2017	GeoB22413-2	20	8.23	0.01	2.51	0.01
27.08.2017	GeoB22413-3	150	7.85	0.02	2.47	0.00
28.08.2017	GeoB22414-9	700	7.84	0.01	2.45	0.01
28.08.2017	GeoB22414-9	500	7.90	0.02	2.47	0.01
28.08.2017	GeoB22414-9	300	8.01	0.01	2.49	0.01
28.08.2017	GeoB22414-9	200	8.05	0.01	2.53	0.02
28.08.2017	GeoB22414-9	100	8.12	0.01	2.56	0.01
28.08.2017	GeoB22414-10	100	8.12	0.01	2.55	0.01
28.08.2017	GeoB22414-10	80	8.18	0.01	2.56	0.00
28.08.2017	GeoB22414-10	60	8.20	0.01	2.56	0.01
28.08.2017	GeoB22414-10	40	8.23	0.01	2.56	0.00
28.08.2017	GeoB22414-10	20	8.24	0.01	2.55	0.01
28.08.2017	GeoB22414-11	150	8.04	0.01	2.51	0.01
30.08.2017	GeoB22416-4	1800	7.93	0.01	2.46	0.02
30.08.2017	GeoB22416-4	1600	7.91	0.01	2.45	0.00
30.08.2017	GeoB22416-4	1250	7.90	0.01	2.46	0.01
30.08.2017	GeoB22416-4	900	7.83	0.02	2.44	0.01
30.08.2017	GeoB22416-4	600	7.82	0.01	2.45	0.01
30.08.2017	GeoB22416-4	330	7.93	0.02	2.47	0.01
30.08.2017	GeoB22416-4	240	7.83	0.01	2.47	0.01
30.08.2017	GeoB22416-4	150	7.98	0.02	2.50	0.01
30.08.2017	GeoB22416-4	100	8.06	0.01	2.52	0.00
30.08.2017	GeoB22416-4	80	8.06	0.01	2.53	0.01
30.08.2017	GeoB22416-4	60	8.05	0.01	2.52	0.00
30.08.2017	GeoB22416-4	40	8.10	0.01	2.54	0.00
30.08.2017	GeoB22416-4	35	8.11	0.01	2.54	0.01
30.08.2017	GeoB22416-4	20	8.23	0.01	2.53	0.00
31.08.2017	GeoB22417-1	700	7.79	0.03	2.44	0.01
31.08.2017	GeoB22417-1	500	7.86	0.01	2.45	0.00
31.08.2017	GeoB22417-1	300	7.94	0.01	2.47	0.00
31.08.2017	GeoB22417-1	200	7.87	0.01	2.47	0.03
31.08.2017	GeoB22417-1	100	8.07	0.01	2.51	0.00
31.08.2017	GeoB22417-2	100	8.08	0.01	2.52	0.01
31.08.2017	GeoB22417-2	80	8.09	0.01	2.52	0.00
31.08.2017	GeoB22417-2	60	failed	failed	failed	failed
31.08.2017	GeoB22417-2	40	8.13	0.01	2.51	0.02
31.08.2017	GeoB22417-2	20	8.26	0.01	2.51	0.00

31.08.2017	GeoB22417-3	150	8.07	0.01	2.52	0.02
03.09.2017	GeoB22421-1	700	7.83	0.01	2.45	0.01
03.09.2017	GeoB22421-1	500	7.87	0.01	2.46	0.00
03.09.2017	GeoB22421-1	300	7.97	0.00	2.48	0.00
03.09.2017	GeoB22421-1	200	8.05	0.02	2.51	0.01
03.09.2017	GeoB22421-1	100	8.17	0.01	2.54	0.01
03.09.2017	GeoB22421-2	100	8.17	0.01	2.54	0.01
03.09.2017	GeoB22421-2	80	8.16	0.02	2.53	0.01
03.09.2017	GeoB22421-2	60	8.19	0.01	2.54	0.01
03.09.2017	GeoB22421-2	40	8.20	0.01	2.54	0.01
03.09.2017	GeoB22421-2	20	8.22	0.00	2.56	0.02
03.09.2017	GeoB22421-3	150	8.10	0.01	2.52	0.01

Table 11.5 Summary of dissolved oxygen measurements during M140

Date	Latitude	Longitude	Station	Depth [m]	Oxygen conc. [mL/L]
12.08.2017	16° 38,87' N	026° 00,84' W	GeoB22402-1	700	4.08
12.08.2017	16° 38,87' N	026° 00,84' W	GeoB22402-1	300	2.25
12.08.2017	16° 38,87' N	026° 00,84' W	GeoB22402-1	100	5.45
12.08.2017	16° 38,87' N	026° 00,84' W	GeoB22402-1	20	6.37
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	700	3.63
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	300	2.09
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	100	5.11
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	20	5.57
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	700	3.74
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	300	2.14
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	100	5.23
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	20	5.23
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	700	2.25
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	300	1.68
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	80	3.40
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	40	5.45
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	700	2.25
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	300	2.25
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	80	2.02
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	40	5.57
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	700	2.14
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	300	2.14
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	80	2.37
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	40	5.45
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	1250	4.31
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	1000	3.28
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	700	1.80
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	400	1.00
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	300	1.68
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	160	2.60
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	100	2.02
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	60	1.68
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	50	2.60
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	40	5.00

21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	30	5.45
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	20	5.23
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	10	5.11
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	700	1.91
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	300	2.37
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	200	2.02
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	80	1.45
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	40	5.00
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	700	2.32
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	300	1.57
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	200	1.80
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	80	2.32
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	60	3.74
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	40	5.57
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	700	2.48
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	300	-
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	200	3.97
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	80	5.00
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	60	5.68
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-3	40	5.68
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-3	300	2.25
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-3	150	3.28
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-3	100	4.08
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-3	80	3.97
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-3	40	4.20
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	100	4.08
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	80	3.97
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	40	4.77
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	1800	5.11
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	150	3.17
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	35	5.11
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	900	3.05
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	330	2.71
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	60	4.08
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	600	2.14
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	700	2.14
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	300	2.48
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	200	2.02
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	80	4.31
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	40	4.65
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-1	700	2.71
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-1	300	3.40
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-1	200	4.20
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-2	80	5.23
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-2	60	6.03
03.09.2017	24°43.73'N	16°34.36'W	GeoB22421-2	40	5.91

Table 11.6: Summary of samples for surface water oxygen and hydrogen stable isotope analysis.

Sample ID		Date [UTC]	Time [UTC]	Latitude	Longitude
δ^{18}O-	δD-				

1	1	11.08.2017	19:37	16°30.829'N	26°28.406 W
2	2	12.08.2017	19:45	15°27.18'N	30°11.03'W
3	3	13.08.2017	21:53	14°16.67'N	34°16.46'W
4	4	14.08.2017	19:17	13°21.154'N	37°28.512'W
5	5	15.08.2017	19:28	12°27.42'N	38°38.47'W
6	6	16.08.2017	20:45	12°22.992'N	38°39.07'W
7	7	17.08.2017	19:06	12°17.702'N	35°49.970'W
8	8	18.08.2017	11:10	11°52.800'N	30°22.002'W
9	9	19.08.2017	20:20	11°47.384'N	28°52.545'W
10	10	20.08.2017	17:41	11°39.051'N	25°48.610'W
11	11	21.08.2017	19:02	11°27.409'N	22°49.987'W
12	12	22.08.2017	19:24	11°20.407'N	22°58.740‘W
rain - 13	rain - 13	23.08.2017	16:00	11°23.46'N	22°53.15'W
14	14	23.08.2017	19:00	11°29.45'N	22°40.28'W
15	15	24.08.2017	20:25	12°08.39'N	23°05.46'W
16	16	25.08.2017	19:10	15°11.17'N	24°15.06'W
17	17	26.08.2017	18:50	17°38.71'N	24°21.28'W
18	18	27.08.2017	18:20	20°13.11'N	21°56.00'W
19	19	28.08.2017	19:30	21°16.88'N	20°49.61'W
20	20	29.08.2017	21:20	21°17.403'N	20°49.492'W
21	21	30.08.2017	19:52	20°50.778'N	18°48.081'W
22	22	31.08.2017	21:37	21°02.17'N	18°45.56'W
23	23	01.09.2017	19:16	20°57.852'N	18°40.925'W
25	25	03.09.2017	18:45	25°18.56'N	16°20.16'W

Table 11.7: Summary of water samples taken for nutrient analysis during M140

Date [UTC]	Latitude	Longitude	Station	Waterdepth [m]
11.08.2017	16° 38,87' N	026° 00,84' W	GeoB22401-1	250
11.08.2017	16° 38,87' N	026° 00,84' W	GeoB22401-1	200
11.08.2017	16° 38,87' N	026° 00,84' W	GeoB22401-1	150
11.08.2017	16° 38,87' N	026° 00,84' W	GeoB22401-1	100
11.08.2017	16° 38,87' N	026° 00,84' W	GeoB22401-1	50
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-1	700
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-1	500
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-1	300
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-1	200
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-1	100
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-2	100
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-2	80
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-2	60
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-2	40
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-2	20
12.08.2017	15°52,24'N	28°44,71'W	GeoB22402-3	150
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	700
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	500
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	300
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	200
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-1	100
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	100
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	80

13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	60
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	40
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-2	20
13.08.2017	14°47,39'N	32°31.44'W	GeoB22403-3	150
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	700
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	500
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	300
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	200
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-1	100
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	100
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	80
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	60
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	40
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-2	20
14.08.2017	13°43.550'N	36°13.398'W	GeoB22404-3	150
15.08.2017	12°24.66'N	38°38.08'W	DVRS6536	140
15.08.2017	12°24.66'N	38°38.08'W	DVRS6536	107
15.08.2017	12°24.66'N	38°38.08'W	DVRS6536	75
15.08.2017	12°24.66'N	38°38.08'W	DVRS6536	60
15.08.2017	12°24.66'N	38°38.08'W	DVRS6536	31
15.08.2017	12°25.40'N	38°40.40'W	DEAY9146	285
15.08.2017	12°25.40'N	38°40.40'W	DEAY9146	221
15.08.2017	12°25.40'N	38°40.40'W	DEAY9146	162
15.08.2017	12°25.40'N	38°40.40'W	DEAY9146	93
15.08.2017	12°25.40'N	38°40.40'W	DEAY9146	41
15.08.2017	12°28.848'N	38°37.131'W	DPHE0358	97
15.08.2017	12°28.848'N	38°37.131'W	DPHE0358	78
15.08.2017	12°28.848'N	38°37.131'W	DPHE0358	53
15.08.2017	12°28.848'N	38°37.131'W	DPHE0358	36
15.08.2017	12°28.848'N	38°37.131'W	DPHE0358	17
15.08.2017	12°30.62'N	38°36.87'W	BXDV7815	262
15.08.2017	12°30.62'N	38°36.87'W	BXDV7815	193
15.08.2017	12°30.62'N	38°36.87'W	BXDV7815	125
15.08.2017	12°30.62'N	38°36.87'W	BXDV7815	83
15.08.2017	12°30.62'N	38°36.87'W	BXDV7815	31
16.08.2017	12°33.05'N	38°39.44'W	JMGX4246	251
16.08.2017	12°33.05'N	38°39.44'W	JMGX4246	218
16.08.2017	12°33.05'N	38°39.44'W	JMGX4246	162
16.08.2017	12°33.05'N	38°39.44'W	JMGX4246	124
16.08.2017	12°33.05'N	38°39.44'W	JMGX4246	67
16.08.2017	12°32.99'N	38°39.48'W	KFVP3225	129
16.08.2017	12°32.99'N	38°39.48'W	KFVP3225	112
16.08.2017	12°32.99'N	38°39.48'W	KFVP3225	78
16.08.2017	12°32.99'N	38°39.48'W	KFVP3225	56
16.08.2017	12°32.99'N	38°39.48'W	KFVP3225	29
16.08.2017	12°31.32'N	38°31.20'W	VWXU0012	124
16.08.2017	12°31.32'N	38°31.20'W	VWXU0012	101
16.08.2017	12°31.32'N	38°31.20'W	VWXU0012	71
16.08.2017	12°31.32'N	38°31.20'W	VWXU0012	49
16.08.2017	12°31.32'N	38°31.20'W	VWXU0012	22

16.08.2017	12°31.15'N	38°30.94'W	BLJO8338	275
16.08.2017	12°31.15'N	38°30.94'W	BLJO8338	209
16.08.2017	12°31.15'N	38°30.94'W	BLJO8338	173
16.08.2017	12°31.15'N	38°30.94'W	BLJO8338	119
16.08.2017	12°31.15'N	38°30.94'W	BLJO8338	67
16.08.2017	12°23.11'N	38°34,68'W	SVBT9363	225
16.08.2017	12°23.11'N	38°34,68'W	SVBT9363	181
16.08.2017	12°23.11'N	38°34,68'W	SVBT9363	141
16.08.2017	12°23.11'N	38°34,68'W	SVBT9363	98
16.08.2017	12°23.11'N	38°34,68'W	SVBT9363	35
16.08.2017	12°23.30'N	38°36.35'W	FUSH5410	131
16.08.2017	12°23.30'N	38°36.35'W	FUSH5410	103
16.08.2017	12°23.30'N	38°36.35'W	FUSH5410	84
16.08.2017	12°23.30'N	38°36.35'W	FUSH5410	50
16.08.2017	12°23.30'N	38°36.35'W	FUSH5410	34
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-1	700
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-1	500
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-1	300
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-1	200
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-1	100
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-2	100
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-2	80
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-2	60
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-2	40
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-2	20
17.08.2017	12°17.70'N	36°56.76'W	GeoB22406-3	150
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	700
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	500
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	300
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-1	100
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	100
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	80
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	60
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	40
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-2	20
18.08.2017	12°06.01'N	33°44.77'W	GeoB22407-3	150
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	700
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	500
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	300
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	200
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-1	100
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	100
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	80
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	60
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	40
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-2	20
19.08.2017	11°52.800'N	30°22.002'W	GeoB22408-3	150
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	700
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	500
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	300

20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	200
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-1	100
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	100
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	80
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	60
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	40
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-2	20
20.08.2017	11°41.35'N	26°39.80'W	GeoB22409-3	150
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	1250
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	1000
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	700
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	400
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	300
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	160
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	100
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	60
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	50
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	40
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	30
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	20
21.08.2017	11°26.20'N	22°49.05'W	GeoB22410-1	10
22.08.2017	11°20.76'N	22°57.58'W	Fox	294
22.08.2017	11°20.76'N	22°57.58'W	Fox	232
22.08.2017	11°20.76'N	22°57.58'W	Fox	176
22.08.2017	11°20.76'N	22°57.58'W	Fox	107
22.08.2017	11°20.76'N	22°57.58'W	Fox	56
22.08.2017	11°20.40'N	22°57.72'W	Goose	139
22.08.2017	11°20.40'N	22°57.72'W	Goose	105
22.08.2017	11°20.40'N	22°57.72'W	Goose	74
22.08.2017	11°20.40'N	22°57.72'W	Goose	41
22.08.2017	11°20.40'N	22°57.72'W	Goose	18
22.08.2017	11°23.161'N	22°59.394'W	Shark	226
22.08.2017	11°23.161'N	22°59.394'W	Shark	189
22.08.2017	11°23.161'N	22°59.394'W	Shark	120
22.08.2017	11°23.161'N	22°59.394'W	Shark	89
22.08.2017	11°23.161'N	22°59.394'W	Shark	42
23.08.2017	11°23.933'N	22°59.649'W	Octopus	131
23.08.2017	11°23.933'N	22°59.649'W	Octopus	115
23.08.2017	11°23.933'N	22°59.649'W	Octopus	81
23.08.2017	11°23.933'N	22°59.649'W	Octopus	60
23.08.2017	11°23.933'N	22°59.649'W	Octopus	31
23.08.2017	11°27.32'N	22°55.47'W	Gull	241
23.08.2017	11°27.32'N	22°55.47'W	Gull	178
23.08.2017	11°27.32'N	22°55.47'W	Gull	137
23.08.2017	11°27.32'N	22°55.47'W	Gull	82
23.08.2017	11°27.32'N	22°55.47'W	Gull	40
23.08.2017	11°26.96'N	22°54.26'W	Cat	130
23.08.2017	11°26.96'N	22°54.26'W	Cat	104
23.08.2017	11°26.96'N	22°54.26'W	Cat	81
23.08.2017	11°26.96'N	22°54.26'W	Cat	51

23.08.2017	11°26.96'N	22°54.26'W	Cat	21
23.08.2017	11°24.77'N	22°54.02'W	Pig	221
23.08.2017	11°24.77'N	22°54.02'W	Pig	178
23.08.2017	11°24.77'N	22°54.02'W	Pig	145
23.08.2017	11°24.77'N	22°54.02'W	Pig	114
23.08.2017	11°24.77'N	22°54.02'W	Pig	58
23.08.2017	11°23.605'N	22°53.214'W	Hedgehog	112
23.08.2017	11°23.605'N	22°53.214'W	Hedgehog	94
23.08.2017	11°23.605'N	22°53.214'W	Hedgehog	61
23.08.2017	11°23.605'N	22°53.214'W	Hedgehog	41
23.08.2017	11°23.605'N	22°53.214'W	Hedgehog	24
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	700
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	500
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	300
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	200
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-1	100
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	100
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	80
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	60
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	40
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-2	20
25.08.2017	14°06.08'N	23°44.68'W	GeoB22412-3	150
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	700
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	500
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	300
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	200
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-1	100
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	100
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	80
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	60
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	40
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-2	20
27.08.2017	19.51.99'N	22°59.07'W	GeoB22413-3	150
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	700
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	500
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	300
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	200
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-1	100
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	100
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	80
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	60
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	40
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-2	20
28.08.2017	21°17.05'N	20°49.27'W	GeoB22414-3	150
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	100
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	80
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	40
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	1800
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	150
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	35

30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	900
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	330
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	60
30.08.2017	20°50.70'N	18°47.96'W	GeoB22416-4	600
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	700
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	500
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	300
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	200
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-1	100
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	100
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	80
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	40
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-2	20
31.08.2017	20°52.19'N	18°56.33'W	GeoB22417-3	150

Table 11.8: Rotation schedule and performance of sediment traps recovered at M3.

Trap mooring 16M3 Upper (PPS5)					
bottle	start	end	days	residue height [mm]	remarks
1	06.04.2016	30.04.2016	24	6.5	
2	30.04.2016	24.05.2016	24	9.5	
3	24.05.2016	17.06.2016	24	9.8	
4	17.06.2016	11.07.2016	24	-	NO BOTTLE
5	11.07.2016	04.08.2016	24	2.5	
6	04.08.2016	28.08.2016	24	-	NO BOTTLE
7	28.08.2016	21.09.2016	24	2.8	bottle base deformed on one side
8	21.09.2016	15.10.2016	24	-	NO BOTTLE
9	15.10.2016	08.11.2016	24	8.5	bottle base deformed and abraded on one side; supernatate discolored and smelly; swimmer?
10	08.11.2016	02.12.2016	24	5.7	bottle base deformed and abraded on one side
11	02.12.2016	14.12.2016	12	1.3	
12	14.12.2016	26.12.2016	12	4.5	
13	26.12.2016	07.01.2017	12	0.0	
14	07.01.2017	19.01.2017	12	0.3	small fish on top of residue
15	19.01.2017	31.01.2017	12	1.3	very small crustacean
16	31.01.2017	12.02.2017	12	-	NO BOTTLE
17	12.02.2017	24.02.2017	12	1.3	
18	24.02.2017	08.03.2017	12	1.7	
19	08.03.2017	01.04.2017	24	8.0	small swimmer on top of residue
20	01.04.2017	25.04.2017	24	12.0	medium shrimp on top of residue
21	25.04.2017	19.05.2017	24	10.5	
22	19.05.2017	12.06.2017	24	6.0	
23	12.06.2017	06.07.2017	24	3.0	
24	06.07.2017	30.07.2017	24	3.0	
Trap mooring 16M3 Lower (PPS5)					
bottle	start	end	days	residue height [mm]	remarks
1	06.04.2016	30.04.2016	24	3.8	bottle 1 probably contains interval 2, etc.
2	30.04.2016	24.05.2016	24	5.0	bottle 2 probably contains interval 3, etc.

3	24.05.2016	17.06.2016	24	4.5	
4	17.06.2016	11.07.2016	24	3.5	
5	11.07.2016	04.08.2016	24	0.0	
6	04.08.2016	28.08.2016	24	4.5	swimmer on top of residue
7	28.08.2016	21.09.2016	24	5.0	
8	21.09.2016	15.10.2016	24	3.8	
9	15.10.2016	08.11.2016	24	2.0	
10	08.11.2016	02.12.2016	24	1.5	
11	02.12.2016	14.12.2016	12	1.0	
12	14.12.2016	26.12.2016	12	1.8	
13	26.12.2016	07.01.2017	12	1.0	
14	07.01.2017	19.01.2017	12	0.5	
15	19.01.2017	31.01.2017	12	1.8	
16	31.01.2017	12.02.2017	12	0.8	
17	12.02.2017	24.02.2017	12	1.0	
18	24.02.2017	08.03.2017	12	2.5	very small crustacean
19	08.03.2017	01.04.2017	24	4.5	
20	01.04.2017	25.04.2017	24	4.0	
21	25.04.2017	19.05.2017	24	3.0	
22	19.05.2017	12.06.2017	24	0.0	
23	12.06.2017	06.07.2017	24	0.3	
24	06.07.2017	30.07.2017	24	-	NO BOTTLE; probably blew out during recovery

Table 11.9: Rotation schedule and performance of sediment traps recovered at M1

Mooring M1 - KUM - 1250 Lower					
bottle	start	end	days	residue height [mm]	remarks
1	18.04.2016	30.04.2016	12	7.5	
2	30.04.2016	24.05.2016	24	3.0	medium shrimp
3	12.05.2016	24.05.2016	12	6.0	
4	24.05.2016	05.06.2016	12	4.5	medium shrimp
5	05.06.2016	17.06.2016	12	5.5	
6	17.06.2016	29.06.2016	12	2.5	
7	29.06.2016	11.07.2016	12	3	
8	11.07.2016	23.07.2016	12	2.7	
9	23.07.2016	04.08.2016	12	7.5	blackisch and smelly
10	04.08.2016	08.08.2016	4	0.5	
11	08.08.2016	12.08.2016	4	1	
12	12.08.2016	16.08.2016	4	0.9	
13	16.08.2016	20.08.2016	4	0.9	small medusid
14	20.08.2016	24.08.2016	4	0.9	
15	24.08.2016	28.08.2016	4	1	
16	28.08.2016	01.09.2016	4	0.8	
17	01.09.2016	05.09.2016	4	1	
18	05.09.2016	09.09.2016	4	0.9	
19	09.09.2016	13.09.2016	4	0.9	
20	13.09.2016	17.09.2016	4	0.9	
21	17.09.2016	21.09.2016	4	1	shrimp
22	21.09.2016	25.09.2016	4	1	medusid

23	25.09.2016	29.09.2016	4	3	
24	29.09.2016	03.10.2016	4	-	rotation failure
25	03.10.2016	07.10.2016	4	-	rotation failure
26	07.10.2016	11.10.2016	4	-	rotation failure
27	11.10.2016	15.10.2016	4	-	rotation failure
28	15.10.2016	19.10.2016	4	-	rotation failure
29	19.10.2016	23.10.2016	4	-	rotation failure
30	23.10.2016	27.10.2016	4	-	rotation failure
31	27.10.2016	31.10.2016	4	-	rotation failure
32	31.10.2016	04.11.2016	4	-	rotation failure
33	04.11.2016	08.11.2016	4	-	rotation failure
34	08.11.2016	12.11.2016	4	-	rotation failure
35	12.11.2016	16.11.2016	4	-	rotation failure
36	16.11.2016	20.11.2016	4	-	rotation failure
37	20.11.2016	24.11.2016	4	-	rotation failure
38	24.11.2016	28.11.2016	4	-	rotation failure
39	28.11.2016	02.12.2016	4	-	rotation failure
Mooring M1 - KUM - 1150 Middle					
bottle	start	end	days	residue height [mm]	remarks
1	02.12.2016	06.12.2016	4	0.4	
2	06.12.2016	10.12.2016	4	2.0	
3	10.12.2016	14.12.2016	4	3.0	
4	14.12.2016	18.12.2016	4	0.5	
5	18.12.2016	22.12.2016	4	0.4	
6	22.12.2016	26.12.2016	4	0.4	
7	26.12.2016	30.12.2016	4	0.4	
8	30.12.2016	03.01.2017	4	0.5	
9	03.01.2017	07.01.2017	4	0.5	
10	07.01.2017	11.01.2017	4	0.5	
11	11.01.2017	15.01.2017	4	0.6	
12	15.01.2017	19.01.2017	4	0.3	
13	19.01.2017	23.01.2017	4	0.3	
14	23.01.2017	27.01.2017	4	0.3	
15	27.01.2017	31.01.2017	4	0.3	
16	31.01.2017	04.02.2017	4	0.3	
17	04.02.2017	08.02.2017	4	0.4	small medusid
18	08.02.2017	12.02.2017	4	12	fluffy
19	12.02.2017	16.02.2017	4	9	fluffy
20	16.02.2017	20.02.2017	4	4	fluffy
21	20.02.2017	24.02.2017	4	0.6	
22	24.02.2017	28.02.2017	4	0.6	
23	28.02.2017	04.03.2017	4	0.4	
24	04.03.2017	08.03.2017	4	0.4	
25	08.03.2017	12.03.2017	4	0.5	
26	12.03.2017	16.03.2017	4	0.7	
27	16.03.2017	20.03.2017	4	0.3	
28	20.03.2017	24.03.2017	4	0.3	medium shrimp
29	24.03.2017	28.03.2017	4	0.2	small shrimp
30	28.03.2017	01.04.2017	4	0.2	small shrimp

31	01.04.2017	05.04.2017	4	0.2	
32	05.04.2017	09.04.2017	4	0.3	
33	09.04.2017	13.04.2017	4	0.3	
34	13.04.2017	17.04.2017	4	0.2	
35	17.04.2017	21.04.2017	4	0.3	
36	21.04.2017	25.04.2017	4	0.2	
37	25.04.2017	29.04.2017	4	0.3	
38	29.04.2017	03.05.2017	4	0.3	
39	03.05.2017	07.05.2017	4	0.3	
Mooring M1 - KUM - 1050 Upper					
bottle	start	end	days	residue height [mm]	remarks
1	01.04.2017	07.05.2017	36	1.0	
2	07.05.2017	11.05.2017	4	0+	
3	11.05.2017	15.05.2017	4	0+	
4	15.05.2017	19.05.2017	4	0.3	
5	19.05.2017	23.05.2017	4	0.2	
6	23.05.2017	27.05.2017	4	0.2	
7	27.05.2017	31.05.2017	4	0.2	
8	31.05.2017	04.06.2017	4	0.2	
9	04.06.2017	08.06.2017	4	0.2	
10	08.06.2017	12.06.2017	4	0.3	
11	12.06.2017	16.06.2017	4	0.2	
12	16.06.2017	20.06.2017	4	0.4	
13	20.06.2017	24.06.2017	4	0.2	
14	24.06.2017	28.06.2017	4	0.3	
15	28.06.2017	02.07.2017	4	0.3	
16	02.07.2017	06.07.2017	4	0.2	
17	06.07.2017	10.07.2017	4	0.2	
18	10.07.2017	14.07.2017	4	0.2	
19	14.07.2017	18.07.2017	4	0.2	
20	18.07.2017	22.07.2017	4	0.2	
21	22.07.2017	26.07.2017	4	0.2	
22	26.07.2017	30.07.2017	4	0.3	
23	30.07.2017	03.08.2017	4	0.3	
24	03.08.2017	07.08.2017	4	0.3	
25	07.08.2017	11.08.2017	4	0.4	
26	11.08.2017	15.08.2017	4	0.4	
27	15.08.2017	19.08.2017	4	0.3	
28	19.08.2017	23.08.2017	4	12.75	
29	23.08.2017	27.08.2017	4	0+	
30	27.08.2017	31.08.2017	4	-	prior to rotation
31	31.08.2017	04.09.2017	4	-	prior to rotation
32	04.09.2017	08.09.2017	4	-	prior to rotation
33	08.09.2017	12.09.2017	4	-	prior to rotation
34	12.09.2017	16.09.2017	4	-	prior to rotation
35	16.09.2017	20.09.2017	4	-	prior to rotation
36	20.09.2017	24.09.2017	4	-	prior to rotation
37	24.09.2017	28.09.2017	4	-	prior to rotation
38	28.09.2017	02.10.2017	4	-	prior to rotation
39	02.10.2017	06.10.2017	4	-	prior to rotation

Table 11.10: Rotation schedule of sediment traps redeployed at M1 (17M1) *RB=reused bottle.

	Lower			Middle		Upper		
	Mooring M1-KUM-1250			Mooring M1-KUM-1150		Mooring M1-KUM-1050		
bottle	start	end	remarks	start	end	start	end	remarks
1	27.08.2017	31.08.2017		30.01.2018	03.02.2018	05.07.2018	09.07.2018	
2	31.08.2017	04.09.2017		03.02.2018	07.02.2018	09.07.2018	13.07.2018	
3	04.09.2017	08.09.2017		07.02.2018	11.02.2018	13.07.2018	17.07.2018	
4	08.09.2017	12.09.2017		11.02.2018	15.02.2018	17.07.2018	21.07.2018	
5	12.09.2017	16.09.2017		15.02.2018	19.02.2018	21.07.2018	25.07.2018	
6	16.09.2017	20.09.2017		19.02.2018	23.02.2018	25.07.2018	29.07.2018	
7	20.09.2017	24.09.2017		23.02.2018	27.02.2018	29.07.2018	02.08.2018	
8	24.09.2017	28.09.2017		27.02.2018	03.03.2018	02.08.2018	06.08.2018	
9	28.09.2017	02.10.2017		03.03.2018	07.03.2018	06.08.2018	10.08.2018	
10	02.10.2017	06.10.2017		07.03.2018	11.03.2018	10.08.2018	14.08.2018	
11	06.10.2017	10.10.2017		11.03.2018	15.03.2018	14.08.2018	18.08.2018	
12	10.10.2017	14.10.2017		15.03.2018	19.03.2018	18.08.2018	22.08.2018	
13	14.10.2017	18.10.2017		19.03.2018	23.03.2018	22.08.2018	26.08.2018	
14	18.10.2017	22.10.2017		23.03.2018	27.03.2018	26.08.2018	30.08.2018	
15	22.10.2017	26.10.2017		27.03.2018	31.03.2018	30.08.2018	03.09.2018	
16	26.10.2017	30.10.2017		31.03.2018	04.04.2018	03.09.2018	07.09.2018	
17	30.10.2017	03.11.2017		04.04.2018	08.04.2018	07.09.2018	11.09.2018	
18	03.11.2017	07.11.2017		08.04.2018	12.04.2018	11.09.2018	15.09.2018	
19	07.11.2017	11.11.2017		12.04.2018	16.04.2018	15.09.2018	19.09.2018	
20	11.11.2017	15.11.2017		16.04.2018	20.04.2018	19.09.2018	23.09.2018	
21	15.11.2017	19.11.2017		20.04.2018	24.04.2018	23.09.2018	27.09.2018	
22	19.11.2017	23.11.2017		24.04.2018	28.04.2018	27.09.2018	01.10.2018	
23	23.11.2017	27.11.2017		28.04.2018	02.05.2018	01.10.2018	05.10.2018	
24	27.11.2017	01.12.2017	*RB	02.05.2018	06.05.2018	05.10.2018	09.10.2018	
25	01.12.2017	05.12.2017	*RB	06.05.2018	10.05.2018	09.10.2018	13.10.2018	
26	05.12.2017	09.12.2017	*RB	10.05.2018	14.05.2018	13.10.2018	17.10.2018	
27	09.12.2017	13.12.2017	*RB	14.05.2018	18.05.2018	17.10.2018	21.10.2018	
28	13.12.2017	17.12.2017	*RB	18.05.2018	22.05.2018	21.10.2018	25.10.2018	
29	17.12.2017	21.12.2017	*RB	22.05.2018	26.05.2018	25.10.2018	29.10.2018	
30	21.12.2017	25.12.2017	*RB	26.05.2018	30.05.2018	29.10.2018	02.11.2018	*RB
31	25.12.2017	29.12.2017	*RB	30.05.2018	03.06.2018	02.11.2018	06.11.2018	*RB
32	29.12.2017	02.01.2018	*RB	03.06.2018	07.06.2018	06.11.2018	10.11.2018	*RB
33	02.01.2018	06.01.2018	*RB	07.06.2018	11.06.2018	10.11.2018	14.11.2018	*RB
34	06.01.2018	10.01.2018	*RB	11.06.2018	15.06.2018	14.11.2018	18.11.2018	*RB
35	10.01.2018	14.01.2018	*RB	15.06.2018	19.06.2018	18.11.2018	22.11.2018	*RB
36	14.01.2018	18.01.2018	*RB	19.06.2018	23.06.2018	22.11.2018	26.11.2018	*RB
37	18.01.2018	22.01.2018	*RB	23.06.2018	27.06.2018	26.11.2018	30.11.2018	*RB
38	22.01.2018	26.01.2018	*RB	27.06.2018	01.07.2018	30.11.2018	04.12.2018	*RB
39	26.01.2018	30.01.2018	*RB	01.07.2018	05.07.2018	04.12.2018	08.12.2018	*RB