ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

740
2020

Berichte
zur Polar- und Meeresforschung
Reports on Polar and Marine Research

The Expedition PS120 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2019

Edited by
Karen H. Wiltshire and Eva-Maria Brodte
with contributions of the participants

HELMHOLTZ

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Titel: TeilnehmerInnen der "schwimmenden Sommerschule SoNoAT"- ein gemeinsames Projekt des Alfred-Wegener-Instituts Helmholtz-Zentrum für Polar- und Meeresforschung, Nippon Foundation-POGO Zentrum für Exzellenz, AtlantOS und desOCEAN TRAINING PORTAL (OTP). Foto: Tim Schauenberg

Cover: Participants of the "floating summer school SoNoAT" - a joint project of the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, the Nippon Foundation - POGO Centre of Excellence, ATLANTOS and the OCEAN TRAINING PORTAL (OTP). Photo: Tim Schauenberg

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Please cite or link this publication using the identifiers

http://hdl.handle.net/10013/epic.4f4fe0a0-faf4-461e-9ed6-d4393b07f287 and
https://doi.org/10.2312/BzPM_0740_2020

ISSN 1866-3192

PS120

Leg 1
02 June 2019 – 20 June 2019
Stanley – Las Palmas

Leg 2
20 June 2019 – 29 June 2019
Las Palmas - Bremerhaven

Chief Scientist
Karen H. Wiltshire

Coordinator
Rainer Knust

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1. ÜBERBLICK UND FAHRTVERLAUF

Karen H. Wiltshire, Eva-Maria Brodte AWI

Die Transitfahrt der *Polarstern*-Expedition PS120 von Port Stanley über Las Palmas nach Bremerhaven startete am 02.06.2019 in Stanley (Falklands) und endete am 29.06.2019 in Bremerhaven.

Die Fahrt teilte sich in zwei Abschnitte auf; der erste führte von Stanley nach Las Palmas vom 02.06 bis 20.06., der zweite von Las Palmas nach Bremerhaven vom 20.6. bis 29.6. Die Reise stand im Zeichnen der studentischen Ausbildung und bediente die Schiffsvorbereitungen für MOSAiC. Eine internationale Gruppe von 23 Studierenden aus 23 Ländern wurde während dieser "schwimmenden Sommerschule" in Techniken der Ozeanographie und der Fernerkundung geschult. Dabei sollten sie Methoden der Probennahme, der Aufarbeitung der Proben und den Umgang mit erhobenen Daten lernen. Als weitere Aufgabe während der Transitfahrt wurden chemische und physikalische Messungen zum Energieaustausch zwischen Ozean und Atmosphäre und bathymetrische Messungen durchgeführt. Zudem bekamen die Studenten eine Einführung in die Physik des Klimasystems, in die internationalen Klimaverhandlungen und Datenanalyse, Mikroplastik & eDNA. Auf dem sogenannten Süd-Nord-Atlantik-Training-Transekt erhielten sie Einblicke in die Meereswissenschaften und führen Kurzprojekte zu den Wechselwirkungen zwischen Ozean, Atmosphäre und Klima durch. Die Vermittlung von Wissen haben die Stipendiaten praktisch an Bord erlernt durch Beteiligung von Schulen aus Portugal, Japan, Irland, Großbritannien und Deutschland, mit denen über Videoverbindung über die Rolle des Ozeans im Klima diskutiert wurde und die Eindrücke der Fahrt und Bewusstsein für das Meer und Veränderungen direkt ins Klassenzimmer getragen wurden. In Leipzig wurde eine Klimakonferenz sächsischer Schülerinnen und Schüler durch einen Videoanruf mit lebhafter Diskussion mit den dort anwesenden 500 Teilnehmenden unterstützt. Direkt von der *Polarstern* aus wurden durch die Fahrtleiterin die aktuellen Ergebnisse der Fahrt beim Klimasymposium in Klimahaus Bremerhaven vorgestellt. Die "schwimmende Sommerschule" war ein gemeinsames Projekt zwischen dem Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, NF-POGO Zentrum für Exzellenz und dem OCEAN TRAINING PORTAL (OTP). Die Sommerschule wurde durch die Nippon Foundation / NF- POGO Centre of Excellence, ATLANTOS und das OTP finanziert und von REKLIM (Helmholtz Verbund Regionale Klimaveränderung) und PORTWIMS (Portugal Twinning for innovation and excellence in marine science and earth observation) unterstützt. Im Rahmen der Vorbereitung der anschließenden MOSAiC Expeditionen wurden Sensoren kalibriert und die Implementierung ins System getestet, um einen reibungslosen Ablauf während des MOSAiC Programms vorzubereiten. Neben den sensor-technischen Vorbereitungen wurde auch die medizinische Abteilung neu organisiert. Am 28.06.2019 lief *Polarstern* in Bremerhaven ein und am 29.06.2019 endete damit die Expedition. Eine Vorstellung der während der Überfahrt durchgeführten Projekte wurde in Bremerhaven öffentlich als Mini-Symposium am Abend der Ankunft vorgestellt.

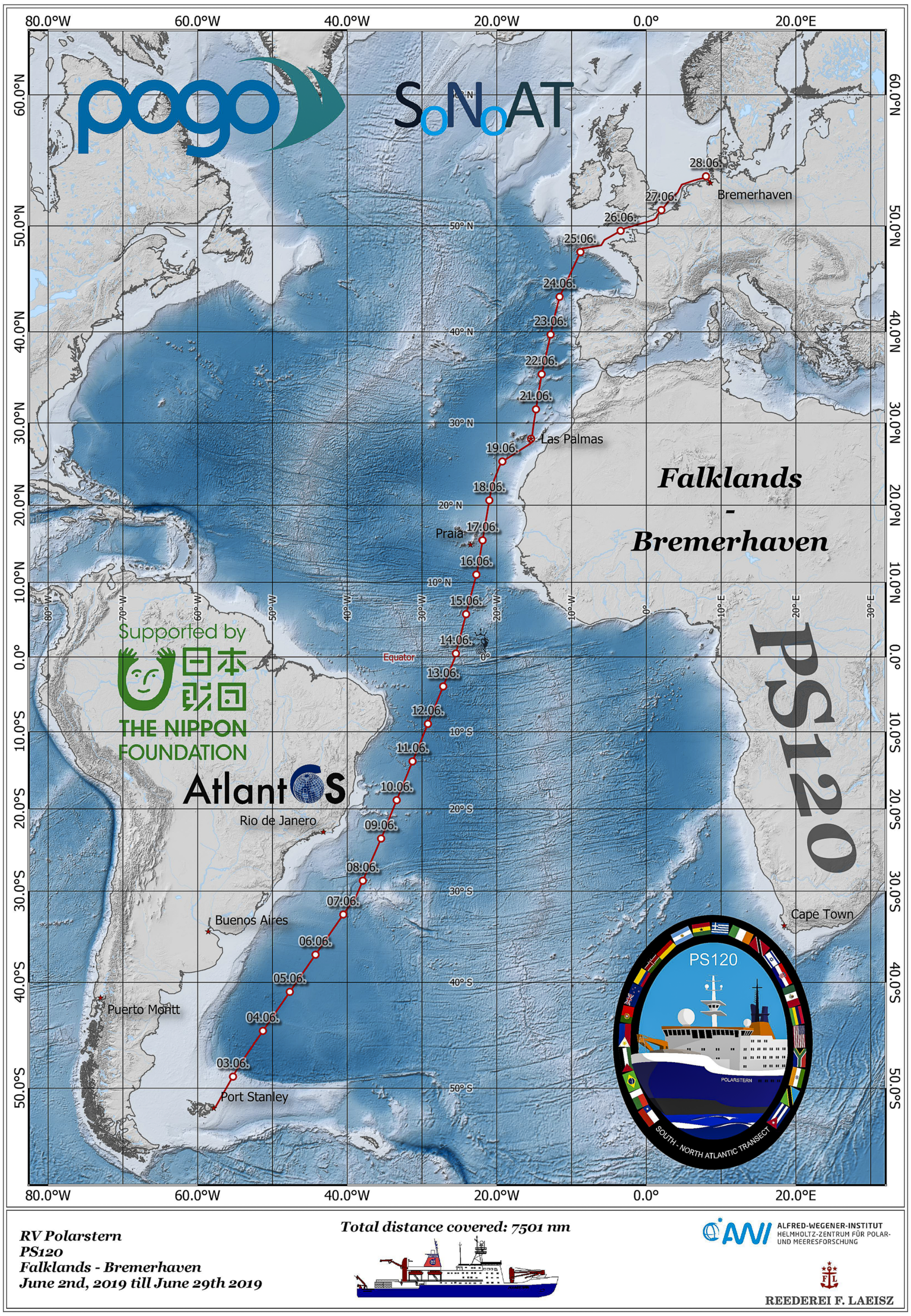

Abb. 1.1: Fahrtroute von Stanley nach Bremerhaven (Karte von I. Nasis). Siehe https://doi.pangaea.de/10.1594/PANGAEA.904054 für eine Darstellung des master tracks in Verbindung mit der Stationsliste für PS120.

Fig. 1.1: Cruise track from Stanley to Bremerhaven (map by I. Nasis). See https://doi.pangaea.de/10.1594/PANGAEA.904054 to display the master track in conjunction with the station list for PS120.

SUMMARY AND ITINERARY

The transit cruise of *Polarstern*-expedition PS120 from Stanley (Falklands) via Las Palmas to Bremerhaven set out on the 02.06.2018 and ended in Bremerhaven on the 29.06.2019. The first leg took part from Stanley to Las Palmas from 02.06. until 20.06.; the second leg took part from Las Palmas to Bremerhaven from 20.06. until 29.06. The cruise was foremost dedicated to the training of students and the preparation and testing of on-board equipment for the upcoming MOSAiC project. During a "floating summer school" an international group of 23 students from 23 countries was trained in basic techniques of oceanography and remote sensing on a North-South transect from Port Stanley to Bremerhaven (South North Atlantic Training; SoNoAT). The participants learned how to take samples, how to process them and deal with the accompanying data. The main water masses between the Atlantic and the North Sea were characterized in terms of their hydrographic features down to a depth of approx. 500 m and more. A further focus during the transit cruise were physical and chemical measurements as well as detection of micro plastics and eDNA. In addition, the students got an introduction into the physics of the climate system, international climate negotiations and data analyses. Prior to the shipboard training a three-day land-based workshop was held to prepare the scholars in application and usage of programming tools and methods. The floating summer school was a joint project between the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, the NF-POGO Centre of Excellence, ATLANTOS and the OCEAN TRAINING PORTAL (OTP). It was funded by the Nippon Foundation / POGO Centre of Excellence and the OTP and supported by REKLIM (Helmholtz Verbund Regionale Klimaveränderung) and PORTWIMS (Portugal Twinning for innovation and excellence in marine science and Earth observation). In preparation for the following MOSAiC expeditions sensors were re-calibrated and configured to fit into the board systems. This assured the functionality during the following MOSAiC programme, the scholar were involved in the sensor testing as well. The *Polarstern* arrived in Bremerhaven on 28.06.2019 and the expedition PS120 ended with a mini symposium on the projects carried out on board for interested public in the evening of the 29.06.2019.

2. WEATHER CONDITIONS DURING PS120

Markus Eifried, Juliane Hempelt, Andreas Raeke DWD

Polarstern expedition 120 was the transfer of the research vessel from the South Atlantic Ocean (Stanley, Falkland Islands) towards the North Atlantic Ocean (Bremerhaven). Since the arrival of the scientific crew on the Falkland Islands was delayed, *Polarstern* departed from the harbour of Stanley in the evening of June 2nd, a few hours later that scheduled.

Week 1, June 2nd – June 9th, 2019

At the beginning of the cruise an extensive gale located over the south-eastern Pacific Ocean west of south Chile dominated the weather conditions upon the South Atlantic Ocean. From this gale a trough extended via the marine area between Argentine and Falkland Islands towards north-east. A high was located north-east of the Falkland Islands. The strong breeze by north-easterly winds shifted with traversing the trough to north-westerly winds on Monday. This breeze continued over the whole week. The reason for this were easterly propagating short-wave troughs of the above mentioned gale which affected *Polarstern* on its north-easterly route in combination with the high, which moved towards east north-east while intensifying. At the beginning it was mostly cloudy to overcast with some rain. In the vicinity of the high the atmosphere became more stable with scattered weather conditions. Singular rain showers from a shallow convection developed in the evening hours. Mean wind force was continuously around 6 Bft, with some little increases and decreases (strongest wind around 7 Bft on June 8th). Wind sea and swell from easterly direction were both between 1.5 and 2 m, sometimes even a little bit more of that. On Sunday *Polarstern* passed the axis of the high pressure ridge and the breeze shifted subsequently towards east south-east, temporarily it calmed down. This was the entry in the trade-wind zone.

Week 2, June 10th – June 16th, 2019

During the second week *Polarstern* cruised through the south Atlantic trade-wind zone. This area was dominated by an extensive subtropical high, which spread out over the whole south Atlantic Ocean. Mainly east south-easterly winds were expected with mean wind force around 5 - 6 Bft. Wind sea and swell were both around 2 m, therefore the significant wave height temporarily was 3 m, the highest significant wave height was registered just a little more than 3 m in the evening of June 12th. The weather state was mainly scattered with some rain showers. *Polarstern* passed the equator on June 14th. Around the equator area *Polarstern* got fair weather with lots of sunshine. The Inner Tropical Convergence Zone (ITCZ) was analyzed between the border area of Guinea and Guinea-Bissau on the West African side via the Atlantic Ocean towards the area between the mouth of Amazon River and French Guiana on the South American continent. *Polarstern* passed the ITCZ in the evening hours of June 15th. The wind shifted to east while decreasing significantly. Wind sea also decreased significantly, swell only little. A second swell spectrum was registered from SSW to SSE directions. Heavy rain showers developed. The highest sea surface temperature with 28.7°C was recorded also on June 15th. On June 16th the wind shifted towards north north-east, this was the entry in the north-east trade-wind zone after passing the ITCZ.

Week 3, June 17th – June 23rd, 2019

The third week was dominated by the north-east Passat wind zone. The subtropical high spread throughout the whole North Atlantic Ocean, its ridge over the area of the Canary Islands extended temporarily towards north-east and developed into a new high over the Bay of Biscay. The thermal low located over Algeria did not change significantly. Wind forces were mostly around Bft 5 with a maximum Bft 6 west of Senegal and Mauritania and a maximum Bft 6 west and east of Gran Canaria due to gap effects. Entering the harbour of Las Palmas was easy due to weak northerly winds. Weather state was continuously fair, wave height was around 2 m. In the area west of Senegal and Mauritania some Saharan dust appeared, but visibility still was good with around 18 km. On Saturday *Polarstern* was affected by week frontal systems of a low west of the Celtic Sea, which shifted eastwards from to area of the Azores towards the cruising area. At that time some drizzle was recorded. The wind shifted back towards south-westerly directions.

Week 4, June 24th – June 29th, 2019

The last week was dominated by an extensive low located west of the Bay of Biscay, which weakened at mid-week. Its frontal system over the British Isles, France and Spain trailed and acted as an air-mass boundary. *Polarstern* approached to this frontal system from time to time and passed that in the English Channel on Wednesday. The wind force mostly was moderate and shifted from southerly towards north-easterly direction. Wave height in the Bay of Biscay was dominated by swell. On Tuesday it was cloudy to overcast with some light rain and in the early Wednesday mist and fog patches appeared in the English Channel. On Wednesday *Polarstern* cruised into the developing ridge of an extensive high located far south of Iceland towards Scotland. The north-easterly mean wind force was Bft 7, wave height around 2,5 m. Entering in the North Sea on Friday high pressure dominated the cruising area. *Polarstern* arrived at the harbour of Bremerhaven in the night from Friday to Saturday.

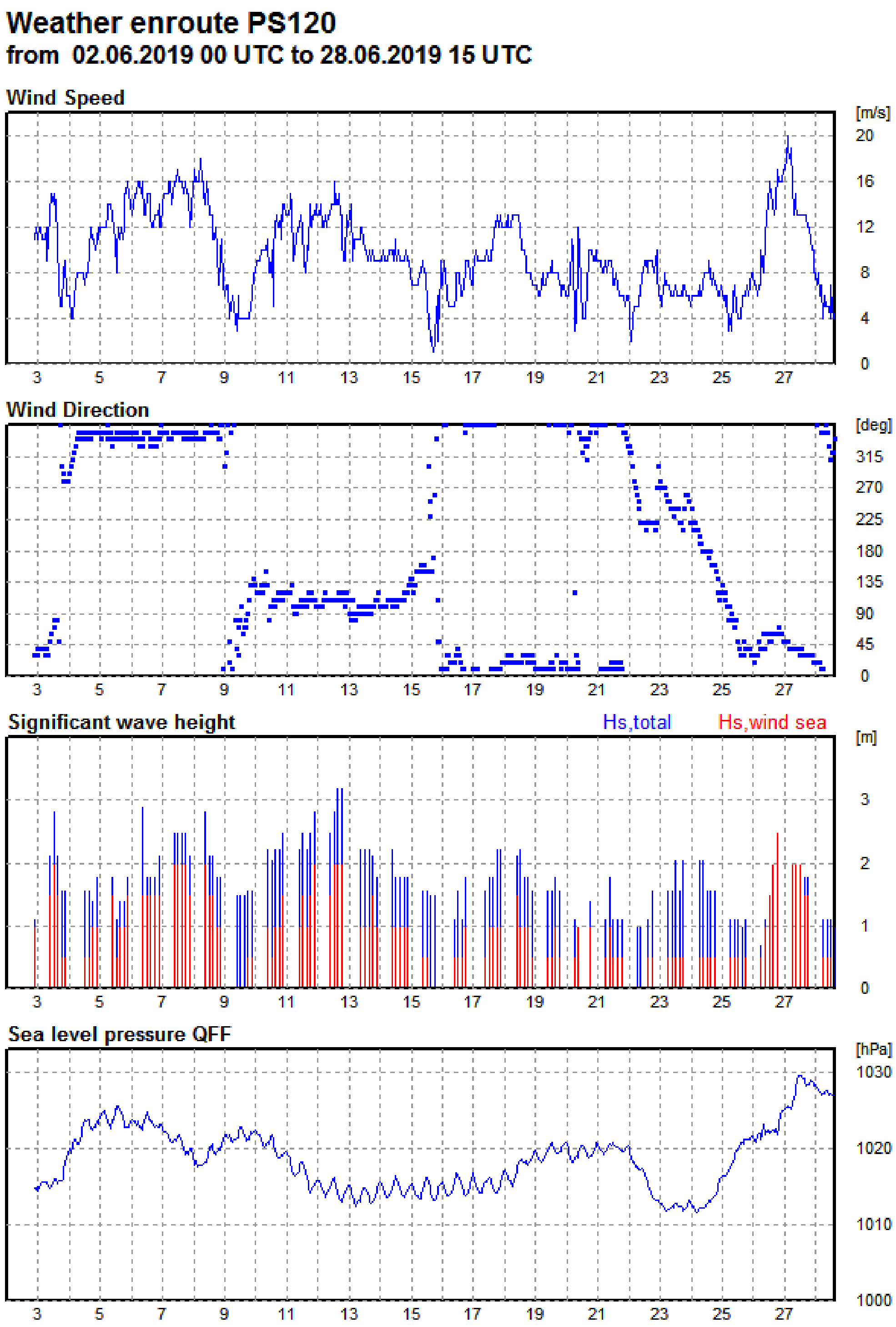

Fig. 2.1: The weather en-route the transit from Stanley to Bremerhaven: wind speed, wind direction, wave height and sea level pressure

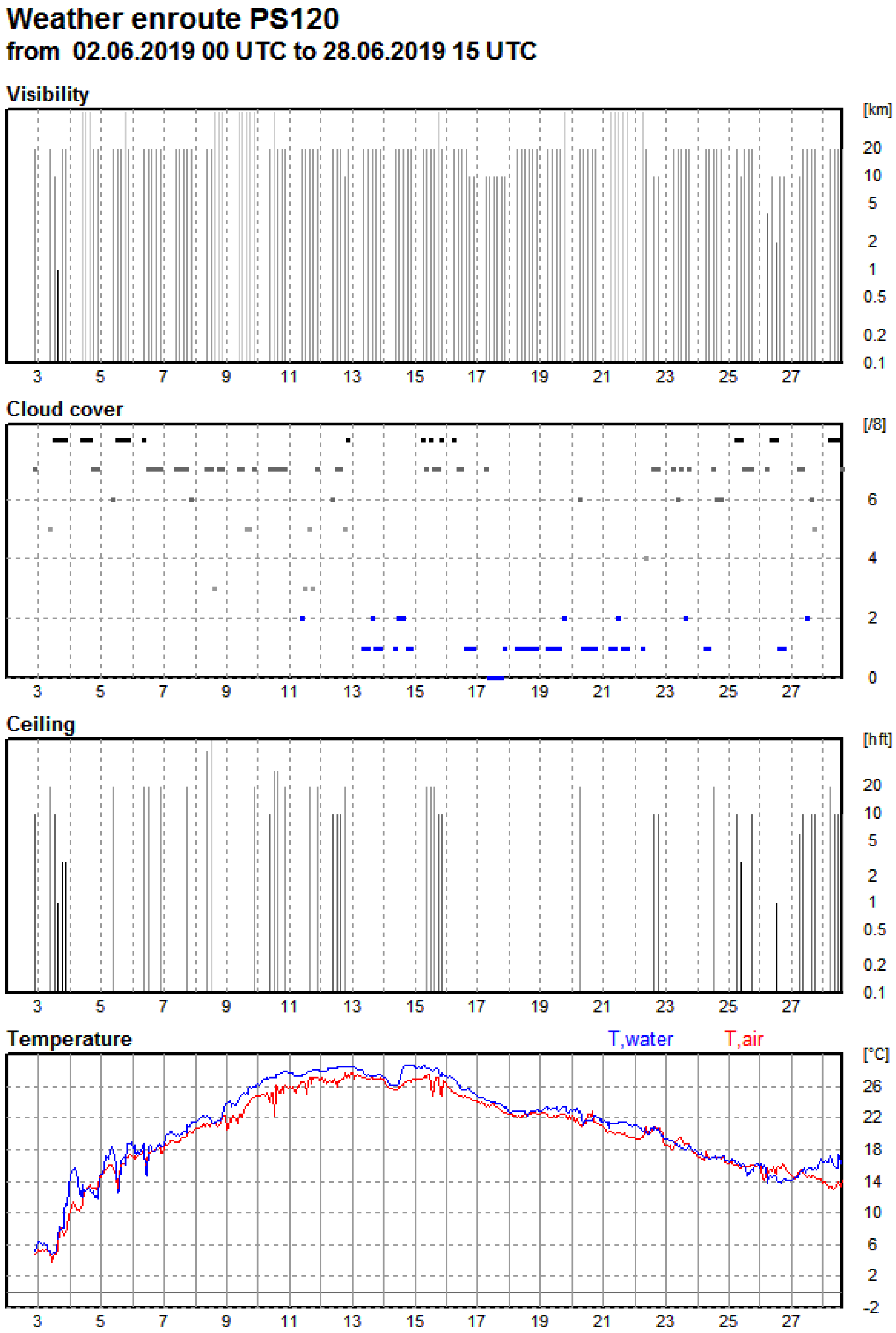

Fig. 2.2: The weather en-route the transit from Stanley to Bremerhaven: visibility, cloud coverage, ceiling and temperature

3. OCEAN AND CLIMATE: TRAINING ON A SOUTH-NORTH ATLANTIC TRANSECT 2019 (SONOAT)

Karen Helen Wiltshire[1], Eva-Maria Brodte[1], Peter Lemke[1], Peter Croot[2], Clynton Gregory[2], Kristine Carstens[1], Mirco Scharfe[1], Eberhard Sauter[1], Anneke Heins[3], Mara Gomez[4], Inga Kirstein[5], Sandi Orlic[6], Santiago Gasso[7], Jan El Kassar[8], Therese Keck[9], Lillian Krug[10]

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Grant-No. AWI_PS120_00

Objectives

Aim of the training programme SoNoAT was to identify and characterize different water bodies along a South–North Atlantic Transect, as part of training exercise for capacity building in oceanography. An international group of 23 students (mostly graduate level and doctoral candidates) was trained in basic oceanographic principles including seagoing methods and sampling associated with these, as well as micro plastic, bacterial and phytoplankton communities in water samples. The cruise track led via cross-coastal, shelf and open Atlantic Ocean waters. Specifically, participants learned how to sample and analyse the ocean properties as “ground truth” information for remote sensing information and how to communicate scientific results to the general public and school kids. The survey participants were divided into groups of four or five, which will rotate between the five main disciplines, which were Climate System, Oceanography, Remote Sensing of Ocean and Atmosphere, Organisms and Micro Plastics and Data Crunching and Statistics (Fig. 3.1).

Additional the scholars were trained in outreach projects as blog writing, conducting short video footages for education purposes, answering questions from school kids via skype etc.

Each group rotation lasted 4 - 5 days and included an average of two stations per rotation. At the end of each rotation, students had a project day set aside to work on preparing that evenings presentation and on individual projects and the hand over to the following group.

In the oceanography module the scholars were introduced to different sampling concepts, sampling planning, sampling techniques, sampling devices, measurement techniques and accuracy, and common oceanographic instrumentation. The gears the scholars were trained in were CTD sensor packages and rosette, expendable Bathythermographs (XBTs), Thermosalinograph/Ferrybox Underway measurements & sampling and deployment of Argo floats. Argo is an international programme that uses profiling floats to observe temperature, salinity, currents, and, recently, bio-optical properties in the Earth’s oceans; it has been operational since the early 2000s. The real-time data it provides is used in climate and oceanographic research. A special research interest is to quantify the ocean heat content (OHC) and therefore an important tool to by trained on.

Fig. 3.1: Rotation scheme of the scholars during the PS120 expedition

As plastics represent the most rapidly growing form of anthropogenic litter entering and accumulating in our oceans, and is therefore a growing threat for humans and nature a module onthis topic was embedded into the sampling routine. By this insights were provided on the abundance, distribution, and composition of microplastics along the South North Atlantic Transect (SoNoAT), which includes open waters, regions of upwelling and varying water masses. Most plastic types are poorly degradable in the marine environment but become brittle and subsequently break down in small particles, so called microplastics. Consequently, marine plastic litter of unknown age and origin can be found in marine waters all over the globe. Investigating particles bigger 250 µm, Kanhai and colleagues (2016) reported average microplastic abundances of 1.15 particles / m^3 on a track from the Bay of Biscay to Cape Town in the Atlantic Ocean. Considering that every plastic item in the ocean will be fragmented over time and that, additionally, every year eight million tons of plastic litter entering the ocean the following assumptions were made. 1. A general increase in microplastic abundance in our oceans over time is likely and 2. With decreasing size, there will be an increase in particle abundance.

Understanding bacterial communities is necessary to understand the environment in which they appear. The unicellular organisms are key degraders of biomass and polysaccharides and drive nutrient fluxes, especially with regard to the carbon cycle (Nagata 2018). They effect all trophic levels and are bound to react to changes in temperature, pH, O2 concentration and other abiotic factors (Boetius 2019). Microbial community determination across the Atlantic has been done before (Agogué et al., 2011), but the generally small percentage of well described (=cultured) strains and infrequent sampling across these transects leaves many uncertainties. Unique sampling cannot show changes in a system, so in order to recognize shifts a repeated analysis with state of the art techniques is required to put the current state into perspective. We compared our results with previous ones and link this information with environmental data (O2, temperature, pH, Chl *a* concentration). These abiotic parameters were used to design appropriate cultivation media that resemble the original water body. Cultivability is known to be low for all bacteria (0.1-1 %, Ferguson et al., 1984). We aimed to collect and freeze stocks to reactivate them at original growth conditions to cultivate new abundant strains. Once in culture these strains could be used for genome sequencing, proteomics, and physiology analysis, opening the door to a better understanding of the Atlantic bacterioplankton and how they are changing in a changing ocean system.

Marine phytoplankton organisms are the main primary producers in our oceans. The essential role of phytoplankton and their value as a highly sensitive ecological indicator makes their study a key approach for evaluation of the status and changes of marine ecosystems, as well as to understand its influence in the pace of climate change. During the SoNoAT expedition, information on phytoplankton was collected through distinct approaches, including both discrete and continuous sampling. The specific objectives of the phytoplankton submodule on PS120 were to

Collect a high spatial and temporal resolved data set on phytoplankton (total and composition) at the subsurface using continuous optical measurements along the cruise transect;

Develop and validate (global and regional) remote sensing algorithms in accordance with the previous objective by using discrete water samples for pigment analysis;

Collect discrete samples for taxa identification through detected morphological features via microscopy;

Obtain a large data set of chlorophyll-*a* concentration (Chl-*a*) for ground-truthing ocean colour satellite data, specifically for the new Sentinel-3 (A and B) OLCI and the Sentinel-5-Precursor TROPOMI sensors;

Identify bio-physical-chemical coupling by using comprehensive data sets to detect shifts in phytoplankton community biomass and composition and the factors driving the variability and changes in the phytoplankton community.

Work at sea

CTD Rosette Sampling

Several hours prior to arriving on station, students were introduced to the basics of CTD operation on the *Polarstern*. They learned how to identify the different sensors on the CTD rosette and how to set and check a Niskin bottle prior to deployment. Scholars were taught how to plan their bottle sampling strategy on the upcast, prior to deployment, based on the expected locations of the different water masses anticipated to be encountered at that location. All deck and winch room operations during deployment were explained to the students prior to beginning the station and they were taught the basic operations of the Seabird CTD software, the event logger on the *Polarstern* and the AWI's ManageCTD programme for post processing of the data into ODV. Students took water samples for dissolved gases, nutrients and phytoplankton from the Niskin bottles for use in other sections of this module. At the completion of the station the students cleaned the CTD and prepared the Niskins bottle set in anticipation of the next deployment.

XBT deployment and data retrieval

Students learned how to setup for an XBT deployment from a moving ship, including communicating with the ship's crew for a safe and successful release of the XBT probe. The students learned how to download the data and to load it into oceanographic software such as ODV.

Water mass identification

Students were introduced to the basics of water mass identification using temperature, salinity and oxygen for the main water masses found along the expedition track. Salinity measurements for CTD calibration were made onboard.

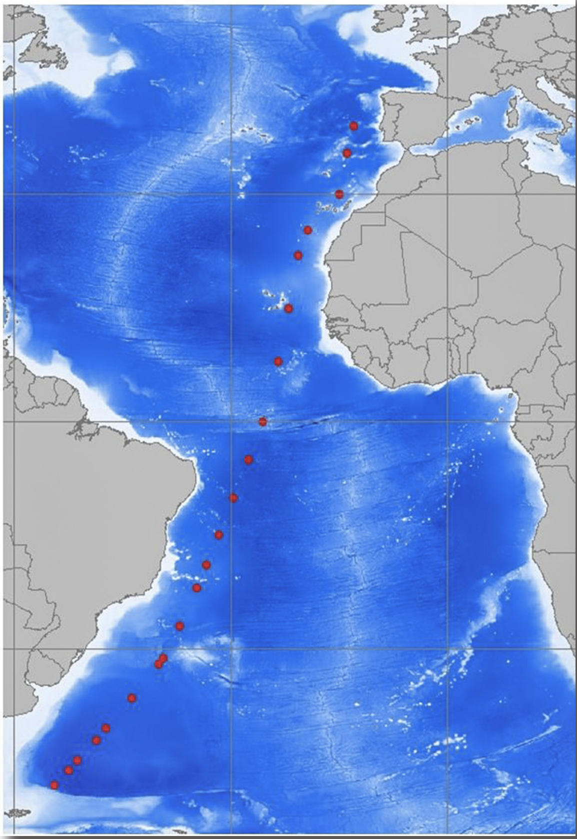

Fig. 3.2: Map of the conducted stations (by Lillan Krug)

Assessing Microplastics in the Atlantic Ocean

To address the abundance, distribution, and composition of microplastics, sub-surface water samples were taken by using an on-board Klaus Union Sealex Centrifugal Pump (Bochum, Germany) and underway pipe system of the *Polarstern* from approximately 11 m depth to the laboratory via stainless steel pipes as first described by Lusher et al. (2014). Two sampling procedures were carried out during the PS120. Firstly, seawater was filtered directly through 10 µm stainless steel filters in a closed steel filter unit to prevent contamination and aim for small microplastics (< 20 µm) (Fig. 3.3A). Secondly, seawater was filtered through geological sieves (bottom: 0.02 mm, centre: 0.2 mm and top: 0.3 mm mesh) enabling the visual inspection, as well as size fractionizing of the sample (Fig. 3.3B). Additionally, and as "proof of concept", water of different depth delivered from the CTD was directly filtered through 10 µm stainless steel filters. All filter meshes from both sampling were stored at -20°C for later polymer analysis in the laboratory.

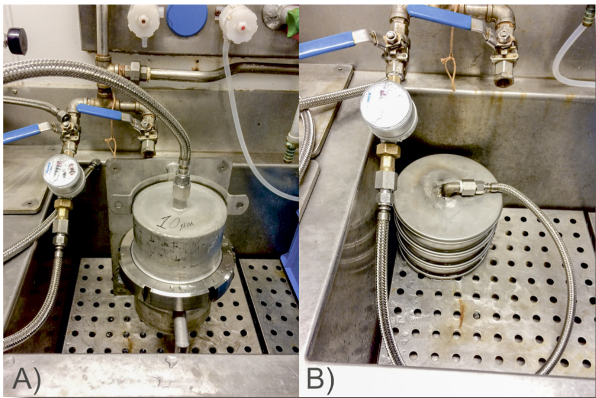

Fig. 3.3: Microplastics on board via the underway seawater system. A) Custom made steel filtration unit (filter 10 µm), B) Geological sieves (bottom: 0.02 mm, centre: 0.2 mm and top: 0.3 mm mesh) with a custom modified stainless steel lid.

Custom made steel filtration unit

The seawater was directly filtered through a 10 µm stainless steel mesh in a custom made closed stainless steel filtration unit (Fig. 3.3), protecting the samples from airborne contamination. Ten samples were taken stationary in parallel to the CTD deployment, further five samples were taken on the transect using this technique (Table 3.1). We aimed for a sample size of 1 m^3. However, the final volume of filtered seawater was dependent on time at the respective station and clogging of the filter.

Tab. 3.1: Summary of closed steel filter system samples for micro plastics on PS120

Date	Sample ID	Coordinates start	Coordinates end	Depth [m]	Volume [L]	Type
04.06.2019	PS_120_S1	44°48.393'S 51°16.770'W		11	1066.2	Station
05.06.2019	PS_120_S2	40°30.055'S 47°14.910'W		11	1007.3	Station
07.06.2019	PS_120_S3	31°11.870'S 39°19.260'W		11	1424.3	Station
10.06.2019	PS_120_T6	19°00.004'S 33°25.807'W	18°35.320'S 33°15.202'W	11	1442.5	Transect
14.06.2019	PS_120_S4	00°00.000'S 25°35.83'W		11	929.2	Station
17.06.2019	PS_120_S5	14°59.998'N 21°59.193'W		11	1050.4	Station
18.06.2019	PS_120_T11	20°26.731'N 21°01.628'W	21°13.033'N 20°53.225'W	11	1039.7	Transect
19.06.2019	PS_120_S6	25°20.144'N 19°23.538'W		11	510.5	Station
20.06.2019	PS_120_T12	27°44.456'N 15°17.293'W	27°57.379'N 15°16.198'W	11	544.3	Transect
21.06.2019	PS_120_S7	30°00.000'N 15°03.000'W		11	807.8	Station
21.06.2019	PS_120_T13	32°11.988'N 14°00.028'W	32°34.667'N 14°33.941'W	11	1189.4	Transect
22.06.2019	PS_120_S8	35°30.014'N 14°00.011' W		11	1344.7	Station
23.06.2019	PS_120_T14	39°00.758'N 13°00.047'W	39°24.391'N 12°53.290'W	11	1076.9	Transect
24.06.2019	PS_120_S9	43°29.892'N 08°36.147' W		11	1162.3	Station
25.06.2019	PS_120_S10	47°59.996'N 08°36.147' W		11	445.7	Station

Geological sieves

Seawater was filtered through geological sieves. In total, 9 samples were taken using a 20 µm sieve combined with 200 µm and 300 µm sieves (Tab. 3.2). Sieves were protected from airborne contamination by a custom modified stainless steel lid, which was directly connected to the seawater pipe by a stainless steel hose in order to prevent airborne contamination (Fig. 3.3). The sample size ranges from 300 L to > 2000 L filtered seawater, which was dependent on clogging of the smallest mesh (20 µm). After every filtration process residues of all involved sieves were pooled in a pre-rinsed glass beaker using pumped seawater from the stainless steel wet lab pipe system and pre-filtered seawater (10 µm) as rinsing agent. The collected material was subsequently filtered through 10 µm stainless steel filters. The filters were stored at -20°C in clean glass petri dishes sealed with aluminum foil.

Tab. 3.2: Summary of geological sieve samples for micro plastics on PS120

Date	Sample ID	Coordinates start	Coordinates end	Depth [m]	Volume [L]	Type
06.06.2019	PS_120_T1	36°53.225'S 44°03.661'W	35°37.550'S 42°58.959'W	11	2001.8	Transect
07.06.2019	PS_120_T2	32°44.883'S 40°35.035'W	32°00.080'S 39°58.396'W	11	2383.3	Transect
08.06.2019	PS_120_T3	28°04.754'S 37°34.397'W	27°18.777'S 37°12.060'W	11	1943.7	Transect
09.06.2019	PS_120_T4	23°52.681'S 35°32.215'W	23°04.546'S 35°10.589'W	11	2068.2	Transect
09.06.2019	PS_120_T5	22°59.276'S 35°08.107'W	22°03.001'S 34°43.699'W	11	688.2	Transect
11.06.2019	PS_120_T7	13°27.168'S 31°04.822'W	12°08.655'S 30°32.101'W	11	1265.8	Transect
12.06.2019	PS_120_T8	09°18.175'S 29°21.568'W	08°05.075'S 28°51.510'W	11	540.0	Transect
13.06.2019	PS_120_T9	04°16.906'S 27°18.235'W	03°10.040'S 26°51.007'W	11	555.4	Transect
16.06.2019	PS_120_T10	10°22.591'S 22°35.83'W	11°28.096'S 22°36.780'W	11	322.6	Transect

Microplastics in the water column

In order to investigate the horizontal distribution of micro plastics in the oceans, we need to develop techniques to sample a sufficient volume of water at different depth in the water column. As a "proof of concept", we filtered water at eight stations of different depth directly through 10 µm stainless steel filters. For the collection of water samples, the CTD-rosette was used. Water samples were taken from Niskin bottles of two or three depths at the respective station (Table 3). We filtered the maximum volume available of each assigned depth, pooling up to three Niskin bottles which resulted in a sample volume between 8.7 to 15.4 L (Table 3.3).

Tab. 3.3: Summary of CTD delivered samples of different depth for microplastics on PS120

Date	Sample ID	Coordinates	Depth [m]	Volume [L]	Type
07.06.2019	PS_120_C1_4478	31°11.870'S 39°19.260'W	4478	11.6	CTD
07.06.2019	PS_120_C1_100	31°11.870'S 39°19.260'W	100	12.5	CTD
10.06.2019	PS_120_C2_1000	18°59.966'S 33°25.866'W	1000	10.7	CTD

Date	Sample ID	Coordinates	Depth [m]	Volume [L]	Type
10.06.2019	PS_120_C2_110	18°59.966'S 33°25.866'W	110	15.4	CTD
14.06.2019	PS_120_C3_3300	00°00.000'S 25°35.83'W	3300	11.6	CTD
14.06.2019	PS_120_C3_40	00°00.000'S 25°35.83'W	40	10	CTD
17.06.2019	PS_120_C4_3500	14°59.998'N 21°59.193'W	3500	12	CTD
17.06.2019	PS_120_C4_60	14°59.998'N 21°59.193'W	60	12.4	CTD
19.06.2019	PS_120_C5_310	25°20.144'N 19°23.538'W	310	11.8	CTD
19.06.2019	PS_120_C5_40	25°20.144'N 19°23.538'W	40	12.2	CTD
21.06.2019	PS_120_C6_3250	30°00.000'N 15°03.000'W	3250	11.8	CTD
21.06.2019	PS_120_C6_1250	30°00.000'N 15°03.000'W	1250	11.6	CTD
21.06.2019	PS_120_C6_75	30°00.000'N 15°03.000'W	75	12.2	CTD
22.06.2019	PS_120_C7_4500	35°30.014'N 14°00.011'W	4500	11.2	CTD
22.06.2019	PS_120_C7_1500	35°30.014'N 14°00.011'W	1500	11.2	CTD
22.06.2019	PS_120_C7_90	35°30.014'N 14°00.011'W	90	12.4	CTD
24.06.2019	PS_120_C8_5000	43°29.892'N 08°36.147'W	5000	10.3	CTD
24.06.2019	PS_120_C8_2000	43°29.892'N 08°36.147'W	2000	8.7	CTD
24.06.2019	PS_120_C8_40	43°29.892'N 08°36.147'W	40	11.2	CTD

Bacterioplankton sampling

Water samples were taken from the Niskin bottles nine stations (Table 3.4) from different depths. They were processed an hour after sampling, starting with the deepest water. A bottle top filtration unit was used and up to two liters were filtered. The filter pore size was 0.2µm (GTTP filters, Millipore) with a pressure ranging from -100 mbar to -500 mbar (average -200 mbar). Filters were stored at -80°C and will be processed on land (Illumina tag sequencing). Glycerol stocks (15 %) of the water samples were taken in triplicates and frozen immediately at -80°C.

Tab. 3.4 Sample locations and number of depths that were analyzed at each station

Date	Latitude	Longitude	Depth [m]
05.06.2019	40°30.070'S	047°15.198'W	9
07.06.2019	31°11.960'S	039°19.376'W	7
10.06.2019	18°59.995'S	033°25.819'W	6
14.06.2019	00°00.012'S	025°35.862'W	6
17.06.2019	15°00.017'N	021°59.305'W	8
19.06.2019	25°20.083'N	019°23.502'W	5
21.06.2019	29°59.957'N	015°03.030'W	7
22.06.2019	35°30.014'N	014°00.011'W	6
24.06.2019	43°29.892'N	011°35.890'W	8

DNA extraction

For some stations (Table 3.4) DNA extraction was done for some filters by the scholars of SoNoAT2019. They either filtered sequentially (10 µm, 3 µm, 0.2 µm filter pore size) and compared the DNA output of different size fractions (Fig. 3.4) or they extracted the DNA of six different depths from the same station (Fig. 3.4). The PowerWater kit (Quiagen) was used for all extractions. An Invitrogen ready-to-use gel (0.8 % agarose, incl. SYBR green) showed the successful extraction of the DNA from more productive zones (Chl a maximum, Fig. 3.4) and the free-living bacterial fractions (<3 µm and >0.2 µm, Fig. 3.4).

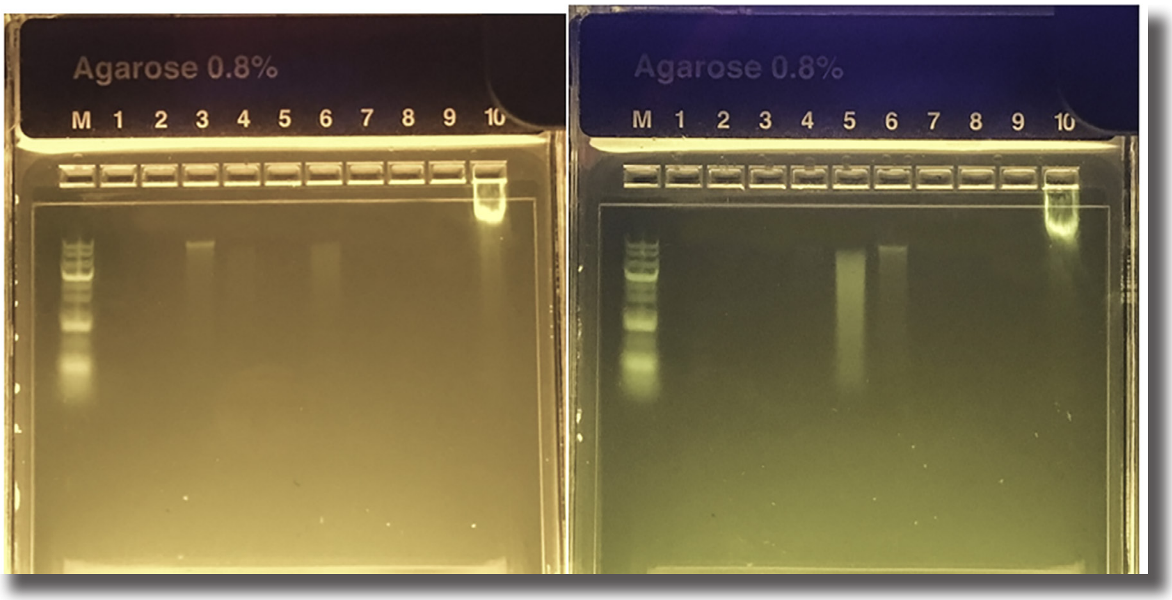

Fig. 3.4: Extracted and stained DNA in a ready-to-use agarose gel. Bands in the M lane represent a 1kb marker. First band 20,000bp and last band 75 bp. Three strong bands are from top to bottom 1,500 bp, 1,000 bp, and 500 bp, respectively. Line 7 to 9 are a negative control with deionized water. Lane 10 is a positive control with 500 µg/ml. A Station 21. Sequential filtration through 10 µm, 3 µm and 0.2 µm filters at 130 m (lane 1 to 3) and at 30 m (lane 4 to 6, chl a maximum). B Station 24. Lane 1 to 6 indicate 5,000 m, 3,500 m, 2,500 m, 1,000 m, 60 m (chl a max), 30 m, respectively.

Valella valella sampling

At station 24 (43° 29.892' N, 011° 35.890' W) the ship encountered few species of *Valella valella*. While being stationary with the ship it was possible to catch five specimens with a bucket. They were photographed, measured and rinsed three times in 0.2 µm filtered seawater, before being transferred into pure EtOH (n=2), 4 % formaldehyde sol. (n=2), or being dissected and put into 15 % glycerol (n=1). The fixed specimen were kept at 4°C, the glycerol stocks were frozen at -80°C.

Assessing phytoplankton communities along the Atlantic Ocean by continuous optical measurements

Continuous measurements of inherent optical properties (IOPs) for the underway surface sampling were performed using an *in-situ* spectrophotometer (AC-S; Wetlabs). The AC-S was operated in a flow-through mode to obtain total and particulate matter attenuation and absorption of surface water with high spectral (4 nm) resolution from 400 to 800 nm. The instrument was connected to a seawater supply system pumping water from 11 m depth through the teflon tubing with a membrane pump. Data processing (following e.g. Liu et al.

2018, Liu et al. 2019) to extract information on phytoplankton biomass and composition from the IOPs will be adapted to the region and further developed by using the discrete *in-situ* samples collected for its validation. The AC-S flow-through system measured continuously from June 4, 2019 01:00 UTC until the 26, of June 2019 12:00 UTC following the cruise track.

Assessing phytoplankton communities along the Atlantic Ocean by discrete water samples

Within the AC-S data acquisition time frame, discrete water samples were taken every 4 hours (at 02:00, 06:00, 10:00, 14:00, 18:00 and 22:00 UTC) from the system outflow water for further pigment analysis, summing a total of 124 underway samples (Table 4.4). For that purpose, the collected water was filtered through glass microfiber filters (47 mm diameter, 0.7 μm pore size).

Tab. 3.5: Summary of the discrete seawater samples taken from the AC-S outflow

Sample ID	Date	Sampling times [UTC]
PS120_ACS_1,2,3,4,5	04.06.2019	02:00, 06:00, 14:00, 18:00, 22:00
PS120_ACS_6,7,8,9,10,11	05.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_12,13,14,15,16,17	06.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_18,19,20,21,22,23	07.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_24,25,26,27,28	08.06.2019	02:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_29,30,31,32,33,34	09.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_35,36,37,38,39,40	10.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_41,42,43,44	11.06.2019	02:00, 06:00, 10:00, 14:00
PS120_ACS_51,52	12.06.2019	18:00, 22:00
PS120_ACS_53,54,55,56,57,58	13.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_59,60,61,62,63,64	14.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_65,66,67,68,69,70	15.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_71,72,73,74,75,76	16.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_77,78,79,80,81,82	17.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_83,84,85,86,87,88	18.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_89,90,91,92,93,94	19.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_95,96,97,98,99,100	20.06.2019	01:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_101,102,103,104,105, 106	21.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_107,108,109,110,111,112	22.06.2019	02:00, 06:00, 10:00, 14:00, 18:00, 22:00
PS120_ACS_113,114,115,116,117,118	23.06.2019	02:00, 06:00, 11:00, 14:00, 17:00, 22:00
PS120_ACS_119,120,121,122,123,124	24.06.2019	02:00, 06:00, 10:00, 14:00, 10:00, 00:00
PS120_ACS_125,126,126,128	25.06.2019	12:00,14:30,18:00,22:00
PS120_ACS_129,130,131	26.06.2019	02:00, 06:00, 10:00

Discrete water samples for further determination of phytoplankton pigment concentration from the Niskin bottles were collected at two depths within the surface ocean layers (surface and chlorophyll maximum) at ten CTD stations (Table 3.6), summing up a total of 21 samples.

These were filtered onboard through glass microfiber filters (47 mm diameter, 0.7 μm pore size) and the filters were stored immediately in the -80°C freezer. After arrival in Bremerhaven, the samples will be sent in dry ice to the Marine and Environmental Science Centre at the University of Lisbon (MARE-ULisbon), in order to be analyzed by High Performance Liquid Chromatography (HPLC). The phytoplankton pigments will be determined following the method of Zapata et al. 2000, within 3 months of samples arrival.

Tab. 3.6: Summary of the discrete water samples taken from the CTD stations for pigment analysis

Sample ID	Date	Coordinates	Sample depth [m]
PS120_CTD1_HPLC_5	04.06.2019	44°48.393'S 51°16.770'W	10
PS120_CTD1_HPLC_75	04.06.2019	44°48.393'S 51°16.770'W	75
PS120_CTD2_HPLC_10	05.06.2019	40°30.055'S 47°14.910'W	10
PS120_CTD2_HPLC_50	05.06.2019	40°30.055'S 47°14.910'W	50
PS120_CTD3_HPLC_10	07.06.2019	31°11.870'S 39°19.260'W	10
PS120_CTD3_HPLC_100	07.06.2019	31°11.870'S 39°19.260'W	100
PS120_CTD4_HPLC_10	10.06.2019	18°59.966'S 33°25.866'W	10
PS120_CTD4_HPLC_125	10.06.2019	18°59.966'S 33°25.866'W	125
PS120_CTD5_HPLC_10	14.06.2019	00°00.000'S 25°35.830'W	10
PS120_CTD5_HPLC_40	14.06.2019	00°00.000'S 25°35.830'W	40
PS120_CTD6_HPLC_10	17.06.2019	14°59.998'N 21°59.193'W	10
PS120_CTD6_HPLC_60	17.06.2019	14°59.998'N 21°59.193'W	60
PS120_CTD7_HPLC_10	19.06.2019	25°20.144'N 19°23.538'W	10
PS120_CTD7_HPLC_120	19.06.2019	25°20.144'N 19°23.538'W	120
PS120_CTD8_HPLC_10	21.06.2019	30°00.000'N 15°03.000'W	10
PS120_CTD8_HPLC_75	21.06.2019	30°00.000'N 15°03.000'W	75
PS120_CTD9_HPLC_10	22.06.2019	35°30.014'N 14°00.011'W	10
PS120_CTD9_HPLC_75	22.06.2019	35°30.014'N 14°00.011'W	75
PS120_CTD9_HPLC_90	22.06.2019	35°30.014'N 14°00.011'W	90
PS120_CTD10_HPLC_10	24.06.2019	43°29.892'N 08°36.147'W	10
PS120_CTD10_HPLC_40	24.06.2019	43°29.892'N 08°36.147'W	40

For assessing coccolithophore taxa, discrete CTD rosette water samples were collected at five distinct depths within the euphotic layer. These were also filtered on board immediately through cellulose nitrate filters (47 mm diameter, 0.45 μm pore size) and filters were stored at room temperature in petri dishes after being washed with tap water (neutralized with sodium carbonate). In total, 38 samples were collected for this purpose (Table 3.7). The filtered material will be used for studies on the distribution and composition of the coccolithophore communities using Scanning Electron Microscope (SEM) at MARE. Species composition and abundance will be determined by identification and counting on measured filter transects. The coccolithophore analysis will be undertaken within a multi-parameter approach, taking into account the hydrographic and meteorological conditions (i.e. temperature, salinity, fluorometry) during the cruise.

Tab. 3 7: Summary of the discrete water samples taken from the CTD stations, for coccolithophore taxa identification

Sample ID	Date	Coordinates	Sample depth [m]
PS120_CTD1_CC_5	04.06.2019	44°48.393'S 51°16.770'W	5
PS120_CTD1_CC_25	04.06.2019	44°48.393'S 51°16.770'W	25
PS120_CTD1_CC_50	04.06.2019	44°48.393'S 51°16.770'W	50
PS120_CTD1_CC_100	04.06.2019	44°48.393'S 51°16.770'W	100
PS120_CTD1_CC_150	04.06.2019	44°48.393'S 51°16.770'W	150
PS120_CTD2_CC_25	05.06.2019	40°30.055'S 47°14.910'W	25
PS120_CTD2_CC_50	05.06.2019	40°30.055'S 47°14.910'W	50
PS120_CTD2_CC_75	05.06.2019	40°30.055'S 47°14.910'W	75
PS120_CTD2_CC_120	05.06.2019	40°30.055'S 47°14.910'W	120
PS120_CTD4_CC_10	10.06.2019	18°59.966'S 33°25.866'W	10
PS120_CTD4_CC_25	10.06.2019	18°59.966'S 33°25.866'W	25
PS120_CTD4_CC_125	10.06.2019	18°59.966'S 33°25.866'W	125
PS120_CTD5_CC_10	14.06.2019	00°00.000'S 25°35.830'W	10
PS120_CTD5_CC_25	14.06.2019	00°00.000'S 25°35.830'W	25
PS120_CTD5_CC_80	14.06.2019	00°00.000'S 25°35.830'W	80
PS120_CTD5_CC_100	14.06.2019	00°00.000'S 25°35.830'W	100
PS120_CTD6_CC_10	17.06.2019	14°59.998'N 21°59.193'W	10
PS120_CTD6_CC_40	17.06.2019	14°59.998'N 21°59.193'W	40
PS120_CTD6_CC_60	17.06.2019	14°59.998'N 21°59.193'W	60
PS120_CTD6_CC_80	17.06.2019	14°59.998'N 21°59.193'W	80
PS120_CTD6_CC_100	17.06.2019	14°59.998'N 21°59.193'W	100
PS120_CTD7_CC_10	19.06.2019	25°20.144'N 19°23.538'W	10
PS120_CTD7_CC_60	19.06.2019	25°20.144'N 19°23.538'W	60
PS120_CTD7_CC_120	19.06.2019	25°20.144'N 19°23.538'W	120
PS120_CTD7_CC_150	19.06.2019	25°20.144'N 19°23.538'W	150
PS120_CTD8_CC_50	21.06.2019	30°00.000'N 15°03.000'W	10
PS120_CTD8_CC_75	21.06.2019	30°00.000'N 15°03.000'W	75
PS120_CTD8_CC_90	21.06.2019	30°00.000'N 15°03.000'W	90
PS120_CTD8_CC_120	21.06.2019	30°00.000'N 15°03.000'W	120
PS120_CTD9_CC_10	22.06.2019	35°30.014'N 14°00.011'W	10
PS120_CTD9_CC_50	22.06.2019	35°30.014'N 14°00.011'W	50
PS120_CTD9_CC_75	22.06.2019	35°30.014'N 14°00.011'W	75
PS120_CTD9_CC_120	22.06.2019	35°30.014'N 14°00.011'W	120
PS120_CTD9_CC_200	22.06.2019	35°30.014'N 14°00.011'W	200

Sample ID	Date	Coordinates	Sample depth [m]
PS120_CTD10_CC_10	24.06.2019	43°29.892'N 08°36.147'W	10
PS120_CTD10_CC_30	24.06.2019	43°29.892'N 08°36.147'W	30
PS120_CTD10_CC_60	24.06.2019	43°29.892'N 08°36.147'W	60
PS120_CTD10_CC_100	24.06.2019	43°29.892'N 08°36.147'W	100

For phytoplankton light-microscopic analysis, 8 discrete samples from the CTD rosette surface and chlorophyll maximum were fixed with Lugol's iodine solution (Utermöhl, 1958) (Table 3.8). For this aim, 200 ml of seawater were added to 12 ml Lugol´s iodine and stored in dark flasks. The analysis will endure at MARE facilities in Lisbon using optical microscopy for cell identification and counting.

Tab. 3.8: Summary of samples collected for microscopy analysis, from CTD stations

Sample ID	Date	Coordinates	Sample depth [m]
PS120_CTD1_Mic_5	04.06.2019	44°48.393'S 51°16.770'W	10
PS120_CTD1_Mic_75	04.06.2019	44°48.393'S 51°16.770'W	75
PS120_CTD5_Mic_10	14.06.2019	00°00.000'S 25°35.830'W	10
PS120_CTD5_Mic_40	14.06.2019	00°00.000'S 25°35.830'W	40
PS120_CTD9_Mic_10	22.06.2019	35°30.014'N 14°00.011'W	10
PS120_CTD9_Mic_90	22.06.2019	35°30.014'N 14°00.011'W	90
PS120_CTD10_Mic_10	24.06.2019	43°29.892'N 08°36.147'W	10
PS120_CTD10_Mic_40	24.06.2019	43°29.892'N 08°36.147'W	40

Deployment of Argofloats (BSH)

The Argo floats were prepared and five floats were deployed underway between the 03.06.2019 and 13.06.2019 with the station numbers PS120_1-1, PS120_2-1, PS120_7-1, PS120_10-1, PS120_14-1. In the appendix the coordinates are listed.

Communication & Ocean Literacy Outreach

During the expedition five blogs were written, social media interactions were undertook and a compilation of the outreach activities was conducted. In total 11 sykpe discussions with school from Ireland, EUK, Brazil, Germany and Japan were conducted, as well as contributions to two climate conferences via skype from sea to shore.

Preliminary (expected) results

Oceanography

The cruise from Port Stanley to Bremerhaven covered an enormous geographic range as we transit through temperate and sub-tropical regions. During the transect, participants were trained in the principles of oceanographic, meteorological, and atmospheric interactions and their impacts on climate.

The gained data allowed the scholars to categorise regional oceanic and atmospheric patterns and identify biogeographic provinces of the Atlantic. The combined results led to this info graphic. This graphic was used to explain not only the result, but as well the methodology to both a scientific audience and the general public.

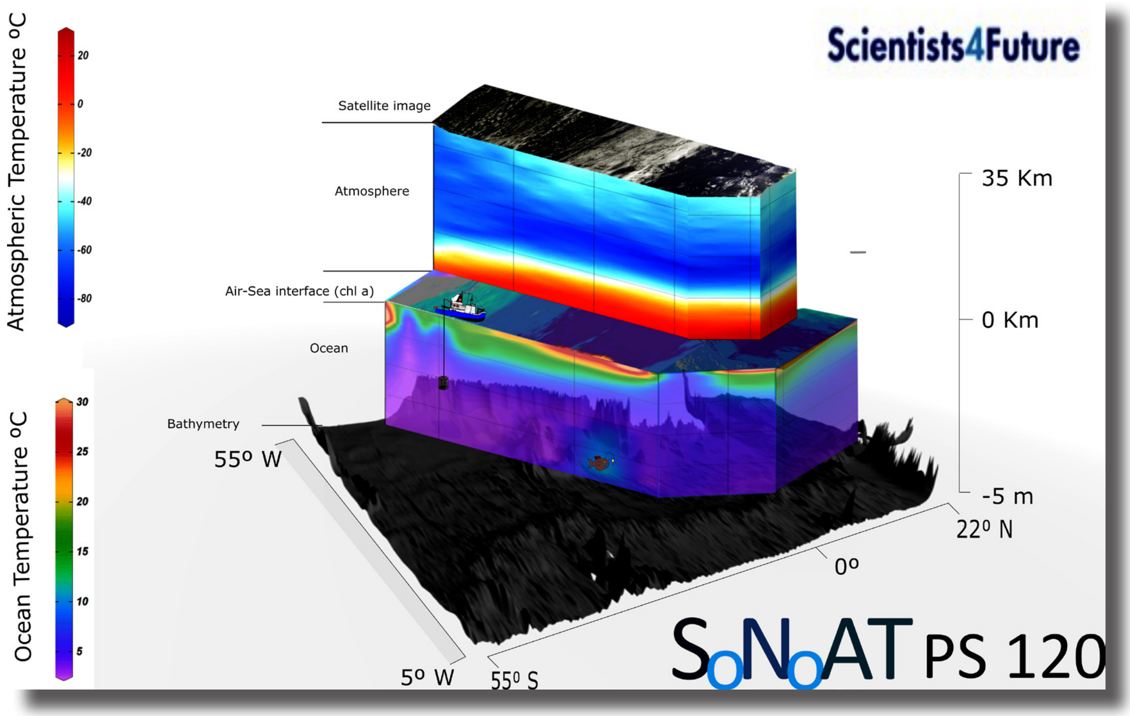

Fig. 3.5: Sampling results of the oceanography and bathymetry group along the transect, combined in an info graphic. The bottom bathymetry is shown from measured data as well as the measured ocean and atmospheric temperature along the transect from Stanley to Bremerhaven. On top of the cube the remote sensing data from satellite imaging depict the combination of several methods.

Assessing mirco plastic in the water bodies

After visual inspection on board there are little indications for micro plastics (> 300 µm) in the samples. However, we observed several floating plastic items on the expedition track e.g. floating plastic sheets, boxes, bottles and buoys. Since bigger plastic items are fragmented over time, we expect to find increasing amounts of micro plastics with decreasing particle size. Therefore, collected micro plastic samples will undergo sample preparation including enzymatic treatment, a density separation (Imhof et al., 2012) and afterwards characterized using focal plane array (FPA) micro Fourier transform infrared spectroscopy (µFT– IR) (Löder et al., 2015).

Bacterial communities from different stations and different depths were compared (Bray-Curtis-dissimilarity, non-metric multidimensional scaling) and statistically evaluated (PERMANOVA and ANOSIM). Species richness, evenness and diversity indices was calculated to provide insights into the communities' ecology.

The collected *Valella valella* specimens at station 24 (43°29.892' N; 011°35.890' W) was analyzed for attached bacteria in different body parts.

Assessing phytoplankton communities along the Atlantic Ocean

The present submodule consisted only in sample acquisition for further analysis and data processing on land. Nevertheless, from visual inspection of the filters on board, a phytoplankton gradient was observed: from the low-productive oligotrophic subtropical gyre regions off the South American coast, to higher productivity waters in the equatorial vicinity, in the West-African and Portuguese coasts and in the Gulf of Biscay. This gradient can also be visualized in the remote sensing derived chlorophyll-*a* concentration considering the available daily data composite for the period of the cruise.

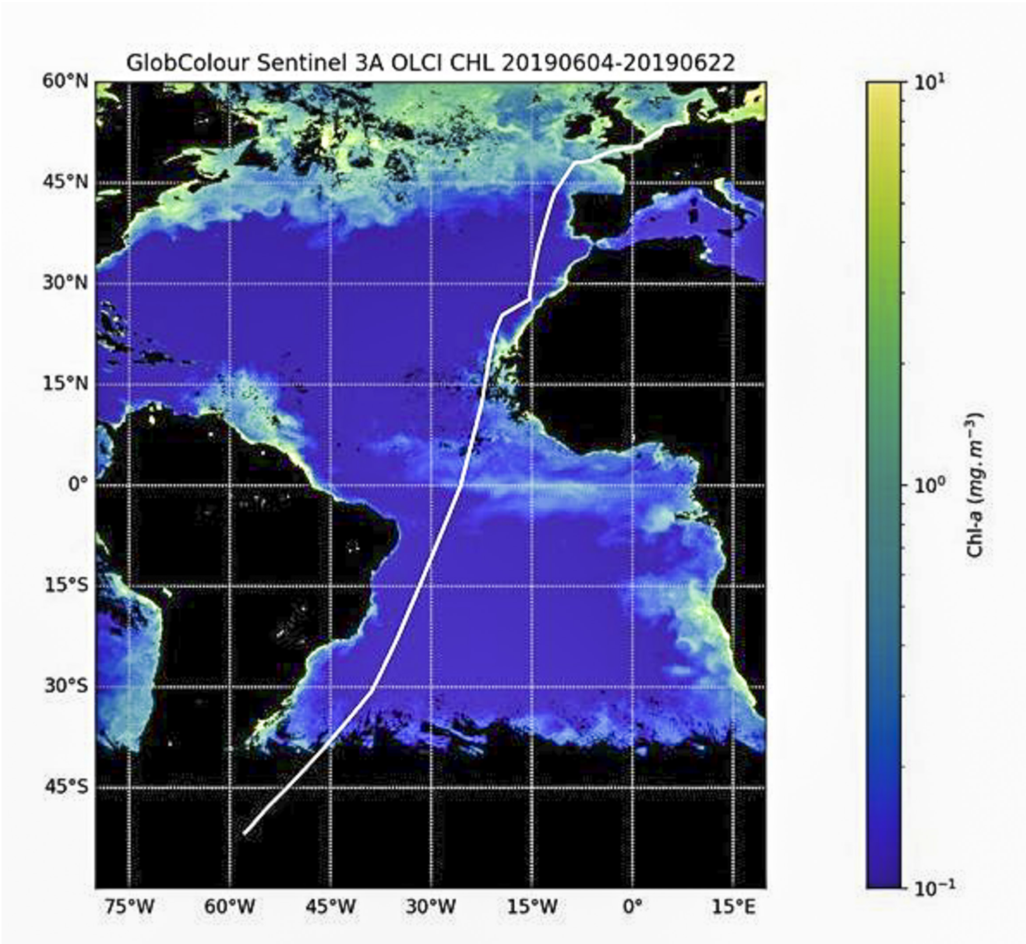

Fig. 3.6: Chlorophyll-a concentration (mg/m³) composite for the period of the cruise along the cruise track (white line). Data from Copernicus GlobColour.

The chlorophyll-*a* concentration calculation from IOPs requires cruise-specific coefficients that can be obtained through determination of the *in-situ* Chl-*a* from HPLC analysis of the filtered material (see Li *et al*. 2018). Nevertheless, from the continuously measured absorption of particulate matter, the total chlorophyll-*a* concentration was calculated for the 19 June 2019 following Li *et al*. 2018, using coefficients derived from the last South-North Atlantic Transect of *Polarstern*, PS113 in 2018 (Fig. 3.8). These can be further compared to the Chl-*a* values obtained using other optical measurements performed on PS120 (i.e., RAMSES and HAMAMATSU), *in-situ* Chl-*a* determined with fluorometric methods, and ocean colour remote sensing data.

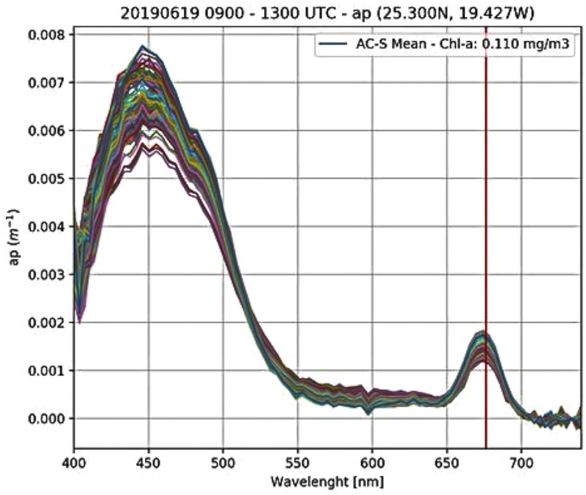

Fig. 3.7: Absorption spectra from AC-S for 19 June 2019, between 09:00 and 13:00 UTC, and derived chlorophyll-a concentration from the absorption line height at 676 nm (red line), according to Li et al. (2018).

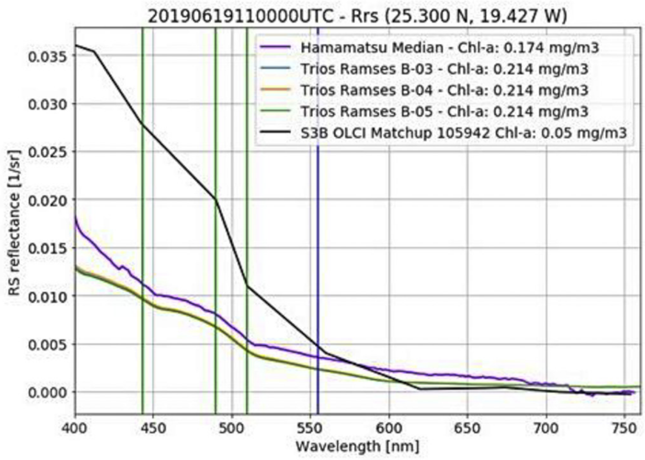

Fig. 3.8: Reflectance spectra from Hamamatsu, Ramses and Sentinel-3B OLCI and respective chlorophyll-a concentration derived using a blue-green ratio for the 19 June 2019. Data from Jan El Kassar.

Communication & Ocean Literacy Outreach

In terms of social media engagement in total 179 posts with #SoNoAT were found done by 79 users. There were 566 engagements and 159.571 impressions reported. In general 77 % of the posts were re-tweeted.

Skype sessions involved eleven schools in five countries (two in Germany, six in the UK, one in Ireland, one in Japan, one Brazil) and a climate conference (Klimakonferenz Wir.Machen. Klima.) in Germany. It was estimated that these audiences included over 150 school children from ages between nine and 18 years old. Furthermore, the *Polarstern* had a live conversation with German-ESA Astronaut Alexander Gerst, who was presenting a seminar at the Alfred Wegener Institute in Bremerhaven. Chief Scientist Prof Karen Wiltshire was invited and conducted a live talk at the international climate symposium (From Copenhagen to Katowice – what has been done so far) at Klimahouse Conference, Germany).

Six blog posts were written by scholars regarding their experience on board (group-written) or personal professional journey (individual-written). The blog posts were published in the Helmholtz/Polarstern webpage (https://blogs.helmholtz.de/polarstern/en/2019/06/) and translated in English, Spanish, Japanese and German.

Data management

All data collected during the expedition are stored in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).at the AWI. The CTD cast data, including bottle files were stored already to download. All other data will be after processing procedures make available in PANGAEA as soon as all lab work is finished.

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4. TESTING OF SENSORS AND CALIBRATION OF MEASURING SYSTEM FOR MOSAIC

Eva-Maria Brodte[1], Peter Lemke[1]

[1]AWI

Grant-No. AWI_PS120_00

Scientific Objectives

The new measuring system for en-route measurements is still under development aiming further improve of the performance, maintainability and field of application of measuring systems currently used on research vessels. Measurements of the different parameters and calibration of sensor ahead the upcoming MOSAIC expedition legs were tested. During the cruise several tests of the new device was performed.

Work at sea

The work on-board included various comparative tests with en-route measuring devices and equilibrators currently used on board *Polarstern*. Work on board was focused on the calibration, installation and integration of all new measuring devices in the existing system and the correct settings, as well as implementing the calibration procedures into a workflow.

Preliminary (expected) results

Workflow procedures of the *en route* pCO_2 measuring devices currently used on board *Polarstern*, data gathered at stations, via the ship systems and salinometer calibrations were synergised with each other.

Data management

Measurements were performed for testing purpose only and did not produce any additional data to the ones logged via the ships system or the salinity calibration. These data will be stored and made available at the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).at the AWI.

5. TESTING OF AN EN-ROUTE MEASURING SYSTEM FOR COMBINED, CONTINUOUS MEASUREMENTS OF PCO$_2$ AND METHANE IN THE SURFACE WATER

Jan Hartmann[1,2], Julian Eschenröder[1,2], Sören Krägefsky[1] and Margot Isenbeck-Schröter[2]

[1]AWI
[2] Uni Heidelberg

Grant-No. AWI_PS120_00

Scientific objectives

High resolution measurements of the different components of the carbon cycle are critical for an understanding of local and large scale processes determining global carbon fluxes. A new measuring system for en-route measurements is under development aiming further improve of the performance, maintainability and field of application of measuring systems currently used on research vessels.

Gaseous carbon dioxide (CO_2) and methane (CH_4) concentrations as well as the stable isotopic values of CO_2 and CH_4 were separated from the water by a membrane contactor and, subsequently, measured by a CRDS device (G2201-i, Picarro®, USA).

Detailed performance evaluations of the new pCO_2 sensor are essential for the further development of the new *en route* measuring device. Therefore, all on-board CO_2 sensors were verified for CO_2 concentrations via subsamples taken from a bypass for later analysis in the laboratories of the Alfred Wegener Institute in Bremerhaven (Germany).

Work at sea

Technical description

During the first leg of PS120 (Port Stanley – Las Palmas), the work on-board included taking water samples from a bypass for later analysis in the laboratories of the Alfred Wegener Institute in Bremerhaven (Germany). These samples will be used for verification and detailed performance evaluation of both on-board pCO_2 sensors (GO-System and OceanPack, subCtech). Due to delays in transportation, the newly developed sensor was not on-board in Port Stanley (Falklands).

In total, 330 water samples were taken during the first 3 weeks of PS120.

During the second leg of PS120, the work on-board included comparative tests of the newly developed measuring device and both *en route* pCO_2 measuring devices currently used on board RV *Polarstern (*GO-System and OceanPack, subCtech). The measurements will be used for comparison in respect to the response times and the stability of the measurements. Further, the system was investigated for its life time during on-board deployment. Additionally, samples from a bypass and from CTD casts from surface water (10 m water depth) were taken for later analysis in the laboratories of the Alfred Wegener Institute in Bremerhaven (Germany).

In total, 82 water samples were taken during the last 6 days of PS120.

Data acquisition and processing

Data acquisition by the new measuring device was carried out throughout the second leg of PS120 between the Las Palmas (Gran Canaria) and Bremerhaven. The new sensor was operated for ~180 h, obtaining ~655’000 data points. The data was stored in DAT raw files.

Additionally, data from both on-board pCO2 sensors (GO-System and OceanPack, subCtech) were collected throughout the entire PS120 cruise between Port Stanley and Bremerhaven. Data were stored in TXT and LOG files, respectively.

Preliminary results

Throughout the second cruise leg between Las Palmas (Gran Canaria) and Bremerhaven, an almost continuous recording of data was achieved. During 6 days of survey, a track length of ~1800 nm (~3’330 km) was surveyed by the newly developed measuring device. This sensor data is consistent with data obtained from both *en route* pCO_2 measuring devices currently used on board *Polarstern*. Fig. 5.1 shows the very preliminary and unprocessed results of the surface water pCO_2 measured by the new sensor and the subCtech sensor.

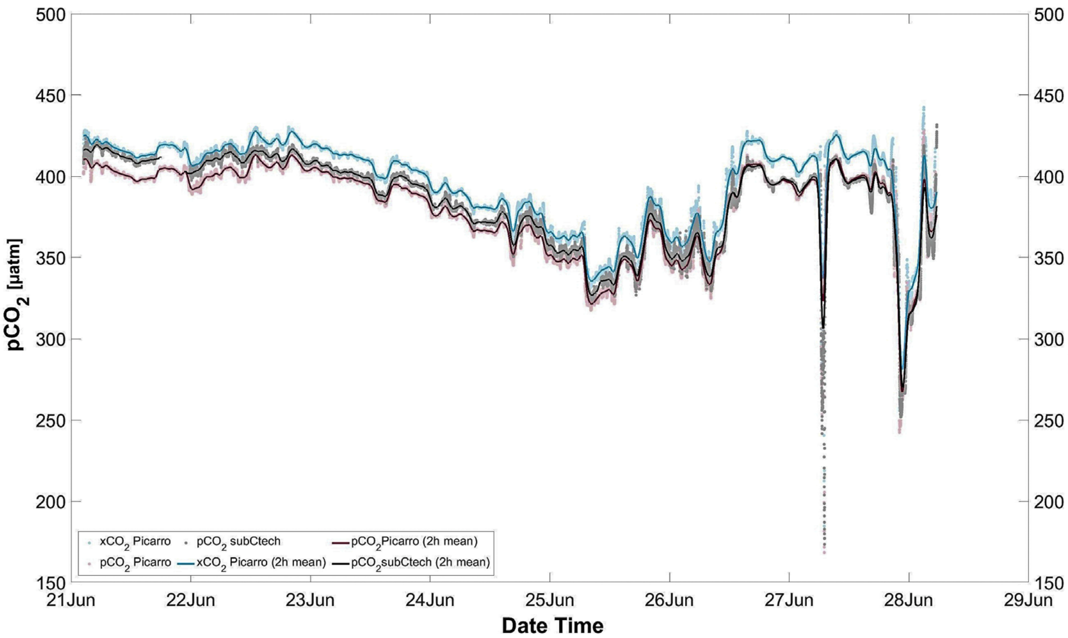

Fig. 5.1: Raw CO_2 data (xCO_2) and calculated pCO_2 data obtained by the prototype (Picarro-based) compared to pCO_2 data obtained by the onboard subCtech system (LI-COR-based).during the second leg of PS120 (Las Palmas (Gran Canaria) and Bremerhaven)

Data management

Measurements were performed for testing purpose only. Surface water pCO_2 data collected during the second leg of PS120 will be used for calibration and characterization work of the newpCO_2 measuring device. Data record will be stored and made available via World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).at the AWI in case of publication of the results of comparative testing.

6. BATHYMETRIC MAPPING AND GEOPHYSICAL UNDERWAY MEASUREMENTS

Simon Dreutter[1], Nina-Marie Lešić[1] [1]AWI

Grant-No. AWI_PS120_00

Scientific objectives

Accurate knowledge of the seafloor topography, hence high-resolution bathymetry data, is key basic information necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Bathymetry, or geomorphology, is a basic parameter for the understanding of the general geological setting of an area and geological processes such as erosion, sediment transport and deposition. Even information on tectonic processes can be inferred from bathymetry. Supplementing the bathymetric data, high-resolution sub-bottom profiler data of the top 10s of meters below the seabed provide information on the sediments at the seafloor and on the lateral extension of sediment successions. This can be used to study depositional environments on larger scales in terms of space and time, of which the uppermost sediments may also be sampled.

While world bathymetric maps give the impression of a detailed knowledge of worldwide seafloor topography, most of the world's ocean floor remains unmapped by hydroacoustic systems. In these areas, bathymetry is modelled from satellite altimetry with a corresponding low resolution. Satellite-altimetry derived bathymetry therefore lack the necessary resolution to resolve small- to meso-scale geomorphological features (e.g. sediment waves, glaciogenic features and small seamounts). Ship-borne multibeam data provide bathymetry information in a resolution that is sufficient to resolve those features.

Additional information that could be collected with ship-mounted sensors is gravimetry and magnetic data to supplement the geophysical dataset and contribute to global data compilations.

Therefore, the main tasks of the bathymetry/geophysics group on board *Polarstern* during PS120 were:

- collection of bathymetric data, including calibration and correction of the data for environmental circumstances (sound velocity, systematic errors in bottom detection, etc.)
- post processing and cleaning of the data
- data management for on-site map creation
- collection of sediment profiling data
- collection of gravimetric data
- collection of magnetic data

Work at sea

Technical description

During the PS120 cruise, the bathymetric surveys were conducted with the hull-mounted multibeam echosounder (MBES) *Teledyne Reson* HYDROSWEEP DS3. The HYDROSWEEP is a deep water system for continuous mapping with the full swath potential. It operates on a frequency of ~14 kHz. On *Polarstern*, the MBES transducer arrays are arranged in a Mills cross configuration of 3 m (transmit unit) by 3 m (receive unit). The combined motion, position (Trimble GNSS), and time data comes from an iXBlue Hydrins system and the signal is directly transferred into the Processing Unit (PU) of the MBES to carry out real-time motion compensation in Pitch, Roll and Yaw. With a combination of phase and amplitude detection algorithms the PU computes the water depth from the returning backscatter signal. The system can cover a sector of up to 140° with each 70° per side. In the deep sea, an angle of ~50° to both sides could be achieved.

The hull-mounted sub-bottom profiling system PARASOUND generates two primary frequencies, of which the lower frequency is selectable between 18 and 23.5 kHz transmitting in a narrow beam of 4° at high power (PHF). As a result of the non-linear acoustic behaviour of water, the so-called "Parametric Effect", two secondary harmonic frequencies are generated, one of which is the difference (e.g. 4 kHz, SLF) and the other the sum (e.g. 40 kHz, SHF) of the two primary frequencies, respectively. As a result of the longer wavelength, the difference parametric frequency allows sub-bottom penetration up to 200 m (depending on sediment conditions) with a vertical resolution of about 30 cm. The primary advantage of parametric echosounders is based on the fact that the sediment-penetrating pulse is generated within the narrow beam of the primary frequencies, thereby providing a very high lateral resolution compared to conventional 4 kHz-systems. For vertical beam transmission (conventional) this capability, however, limits good survey results on sea-floor slopes, which are inclined to more than 4° relative to horizontal. The reason is that the energy reflected from the small inclined footprint on the seafloor is out of the lateral range of the receiving transducers in the hull of the vessel.

Data acquisition and processing

Data acquisition was carried out throughout the entire cruise leg between the Falkland Islands and Gran Canaria (except for a short break to conduct testing of the synchronization unit).

The MBES was operated with Hydromap Control and for online data visualization, Teledyne PDS was used. The collected bathymetry was stored in ASD and S7K raw files.

Subsequent data processing was performed using Caris HIPS and SIPS. For generating maps, the data were exported to Quantum GIS in the *GeoTIFF* raster format.

The PARASOUND was also operated with Hydromap Control and the data was visualized in Parastore. Acquisition included PHF and SLF data. Both PHF and SLF traces were visualized as online profiles on screen. SLF profiles (200-m-depth window) and online status reports (60-s-intervals or shorter) were saved as PNG files.

For the entire period above, and simultaneously with sounding, six different types of PARASOUND data files were stored on hard disc:

- - PHF data in ASD format
- - PHF data in PS3 format (carrier frequency, lat.long)

- - SLF data in ASD format
- - SLF data in PS3 format (carrier frequency, lat.long)
- - Navigation and Auxiliary data (60s intervals) in ASCI format
- - SLF Online “Prints” as A-4 pages in PNG format
- - PARASTORE 3 settings in XML files

Sound velocity profiles

For best survey results with correct depths, the CTD (Conductivity, Temperature, Depth) casts, performed by the oceanographic working group, were used to measure the water sound velocity in different depths. This is essential, as the acoustic signal travels down the water column from the transducer to the seafloor and back to the surface through several different layers of water masses with each a different sound velocity. The sound velocity (SV) is influenced by density and compressibility, both depending on pressure, temperature and salinity. Wrong or outdated sound velocity profiles lead to refraction errors and reduced data quality.

The CTD measures conductivity, temperature, and depth in the water column while it is lowered to the seafloor. From these parameters, the sound velocity is calculated.

The sound velocity profiles obtained by the CTD were immediately processed and applied within the MBES for correct beamforming during the survey.

Additionally, the daily xBT (Expandable Bathythermograph) temperature profiles in combination with WOA13 (World Ocean Atlas 2013) salinity profiles were used to create SV profiles.

Preliminary results

Throughout the first cruise leg between the Falkland Islands and Gran Canaria, an almost continuous recording of data was achieved. During 17 days of survey, a track length of 5,527 nm (10,235 km) was surveyed by the swath bathymetry and the sub-bottom profiling system. Fig. 6.1 shows the generated bathymetry grid over the Atlantic.

Data management

Bathymetric data collected during PS120 will be stored in the PANGAEA data repository at the AWI. Furthermore, the data will be provided to mapping projects and included in global bathymetry compilations such as GEBCO (General Bathymetric Chart of the Ocean). Bathymetric data will also be provided to the Nippon Foundation – GEBCO Seabed 2030 Project. All PARASOUND data will be transferred to AWI after the cruise and stored in the data base of the IT section. Once georeferenced, the data will be linked for external accessibility in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).at the AWI. Magnetic and gravimetric data will be stored at the AWI, processed in combination with reference measurements on land (Las Palmas and Bremerhaven) and finally submitted to PANGAEA.

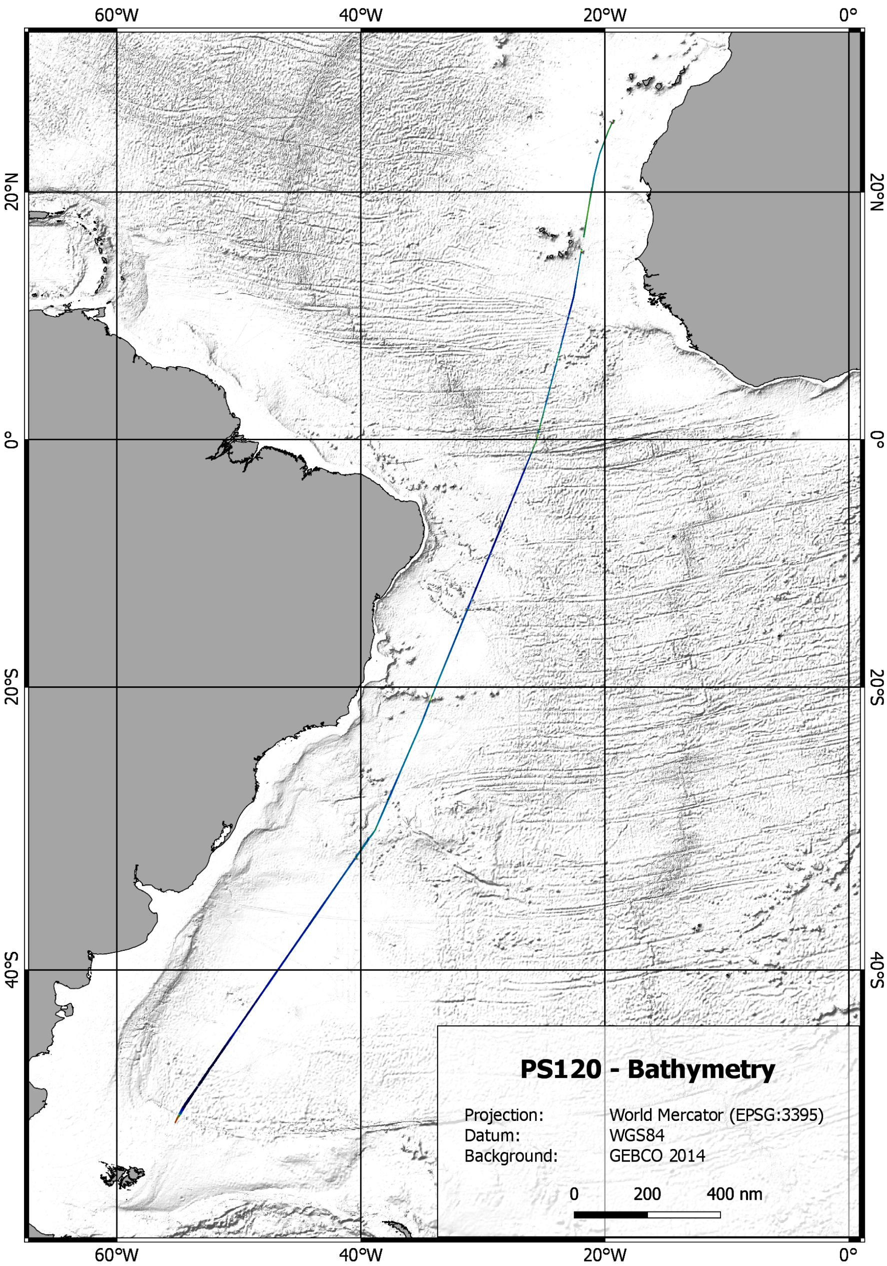

Fig. 6.1: Overview on the bathymetric data acquired during PS120

7. OBTAINING CHLOROPHYLL-*A* FROM FIELD REFLECTANCE SPECTRA OF MEASUREMENTS AND AEROSOL-OPTICAL THICKNESS FROM SUNPHOTOMETER

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Grant-No. AWI_PS120_00

Scientific objectives

Optical devices enable us to obtain data without physical contact. Spectral measurements in the field on board *Polarstern* PS120 can be used to validate space borne satellite measurements from e.g. OLCI on board Sentinel-3A and Sentinel-3B or MODIS on board Aqua and Terra. Their data provide well spatio-temporal resolved information of the expedition track and its environment. Additionally, spectral ocean color measurements supports continuous data time-series as no ship-time is required.

Ocean Color measurements (reflectance) are used to obtain chlorophyll-*a* (Chl-a) concentration as a proxy for phytoplankton amount in the upper ocean layer. Sun-photometers gained information about aerosols via the aerosol-optical thickness that can support atmospheric correction of space-borne data.

Work at sea

Technical description

Spectroradiometers Ramses and Hamamatsu

Measurements with Ramses (TriOS) were conducted on a daily base if weather conditions were appropriate (no rain, as few clouds as possible). Standard measurement time was 1,300 ship-time which were shifted to late morning or afternoon according to weather.

Measurement activities were independent from ship stations. However, during day-stations with CTD and BBE measurements, we measured spectra during station time to use calm water and in order to compare to Chl-a measurements.

Measurement location was the top measurement deck towards the bow. Depending on the azimuth angle of the sun relative to the ship, spectra were obtained either from port or starboard side.

Each activity contained 2-4 measurement “rounds” which contain three types of spectra each according to IOCS ocean optics protocol (CITE) and eq. (1). We took at least 10 samples for each type (see subsection Data Acquisition) in case of outer influences or miss-measurements.

Measurements with Hamamatsu were conducted similarly to Ramses, however, all three measurements could be taken at once by three Hamamatsu devices installed in a plastic box. Irradiance Ed was obtained directly by a Hamamatsu irradiance sensor.

Hamamatsu ran in burst-mode taking a bunch of samples in a short time-period of 30-60 s while holding the devices platform over the reeling. Additionally, black current with closed sensors were measured to reduce actual measurement sample spectra from sensor-specific influence.

Microtops Radiometers

The Microtops radiometers are handheld small devices that measure atmospheric radiance at 5 wavelengths (670, 879, 910 nm and two other optional wavelengths). Their main output product are aerosol optical depths (AOD) at four wavelengths and total column water vapor.

They can be operated anytime if there are clear sky conditions. Three instruments were brought on board (labeled M1, M3 and M4). M1 and M3 are identical with 4 operating channels (440, 670, 879 and 910 nm). M4 had a 5th channel at 1.310 nm and it is a test model since the near-IR filter has never been used with a Microtops.

During clear sky conditions, measurements were attempted to conduct. During full clear sky days, observations were carried out at intervals every 30 to 120 min depending on the work load during SoNoAT summer school.

An observation period consisted on connecting the GPS unit to the Microtops, turn instrument on and then point it to the Sun. 6 to 15 consecutive scans (about 5 seconds each) were carried out two times in an interval of 2-5 min.

Data acquisition and processing

Ramses and Hamamatsu

Ramses measures directed intensity (radiance) in a spectral range from 350 nm to 1,000 nm. Hamamatsu setup contains two radiance sensors and one irradiance sensor which measure in the visible to infra-red range as well.

After removing off-measured spectra, the remaining sample spectra are geometrically averaged per activity and activity round.

In order to calculate the Remote Sensing Reflectance R_{RS} in eq. (1),

three types of spectral measurement are obtained:

$$R_{RS}(\lambda) = \frac{L_w}{E_d} = \frac{L_u(\lambda) - \rho L_{sky}(\lambda)}{\pi L_d(\lambda)} \quad (1)$$

- Downwelling radiance L_d (see Fig. 7.1a) above a Grey Plate in nadir view (180°) to obtain “incoming” light,
- Upwelling radiance L_u (see Fig. 7.1b) from the ocean with viewing zenith angle (VZA) of 140° and relative azimuth angle (RAA) of 135° away from sun, and
- Diffuse sky radiance L_{sky} (see Fig. 7.1c) with in RAA=135° and VZA=40°.

For Ramses, VZA and RAA are set up by an optical platform installed on the reeling. For Hamamatsu, VZAs are internally fixed inside the plastics box while RAA had to been taken into account.

Due to isotropic reflectivity of 20 % within visible spectral range of the Grey Plate (LabSphere), the downwelling irradiance for Ramses is obtained by integrating measured L_d over the hemisphere by eq. (2).

$$E_d = \int_0^{2\pi} \int_0^{\pi/2} \frac{L_d}{0.2} sin\theta cos\theta d\theta d\phi = \pi L_d (2)$$

Hamamatsu set-up provides an irradiance sensor.

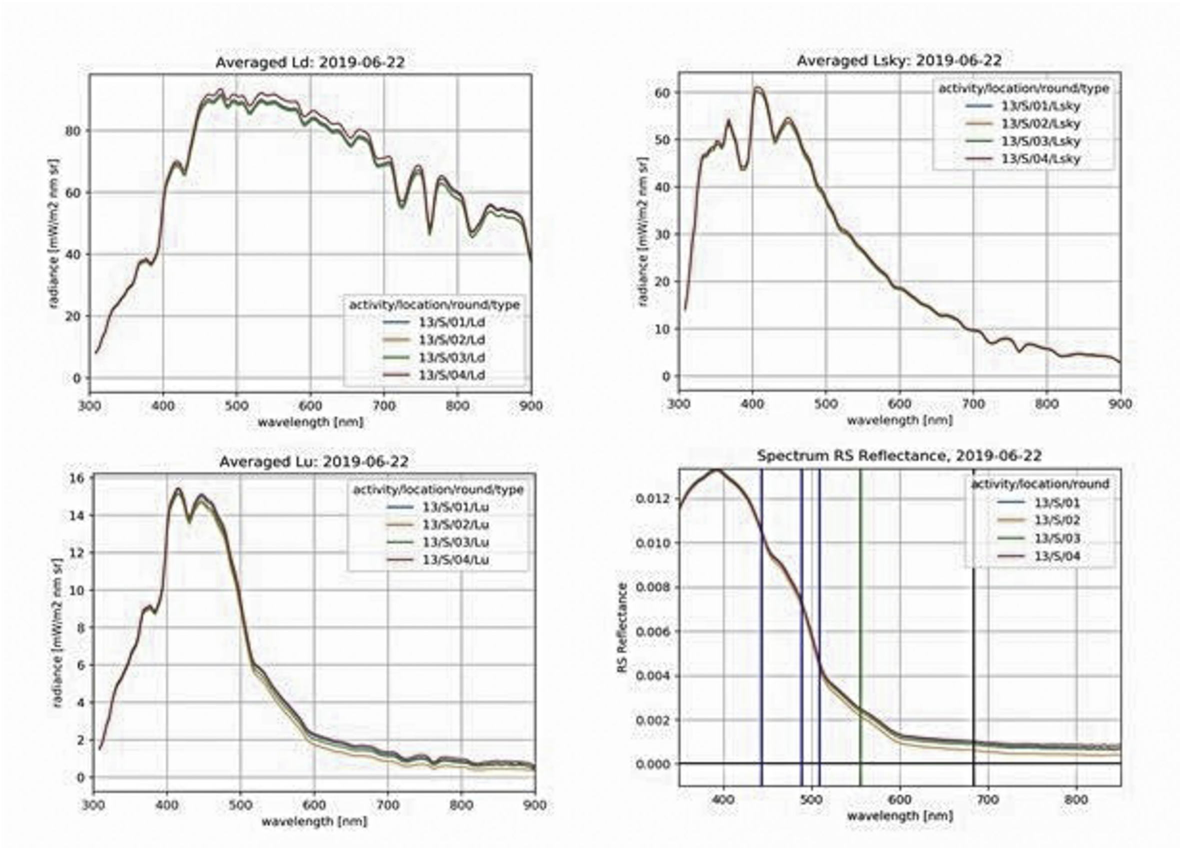

Fig. 7.1: Example measurements (averaged after cleaning data) for 2019-06-22, activity 13 with 4 rounds. 7.1a (upper left) shows Ld as it was measured over the Grey Plate. 7.1b (upper right) and 7.1c (lower left) show diffuse sky radiance and upwelling radiance from ocean. 7.1d (lower right) shows resulting reflectance.

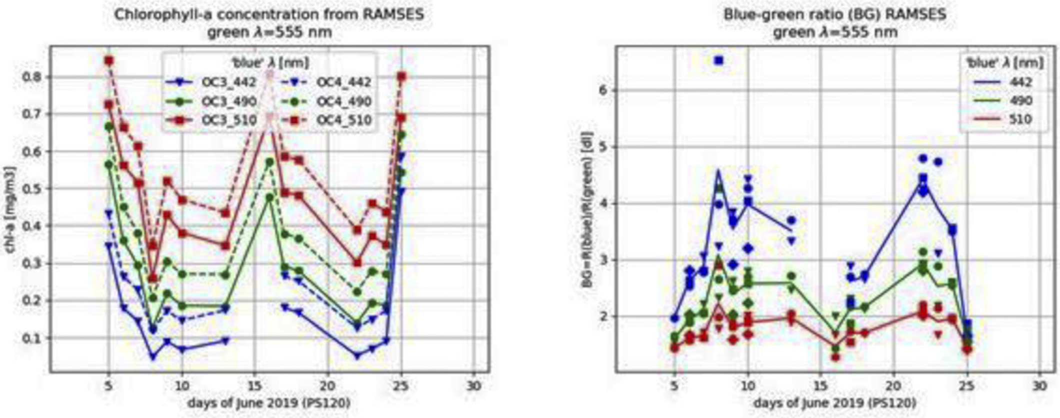

Fig. 7.2: Left: chlorophyll-a concentration of upper layer for each RAMSES measurement activity. Right: corresponding blue-green ratios.

Upwelling radiation contains reflected diffuse sky light Lsky and water-leaving radiation Lw which contains actual information about water condition and water constituents.

The remote sensing reflectance is calculated with Python to be able to compare different surface waters or similar water in different outer illumination light field (see example in Fig. 7.1).

Spectral information from calculated reflectance spectra from Hamamatsu and Ramses can be used to obtain chl-a concentration [mg m-3] with a case-1 bio-optical model (e.g. OC3 or OC4Me, see section Preliminary Results).

Microtops

If clear sky conditions prevail, the consecutive observations can be averaged and then used as representative value of the period. If the sky is partly cloudy, cloud contamination is very likely and those observations are removed by hand. Cloud contaminated observations are very clear to detect in the data since they are sudden spikes of AOD usually above the value of 0.8 (typical AOD values are <0.4 unless in a pollution event).

Preliminary Results

Aerosols

The observations with the Microtops M4 along the transect from Falklands Islands to North of Cape Verde is shown Fig. 7.2.

In Fig. 7.3, the spikes in the data are due to cloud contamination which have not been removed yet.

In Fig. 7.3, the Ångström Exponent (AE) plot shows the raw data and a 7 point running average for clarity (red line). AOD values below 0.15 are considered background values. Typically, they are representative of air masses from clean environments as the South Atlantic and this is the case in the observations until reaching the tropics (~ 14-10 S) when AOD values start to increase.

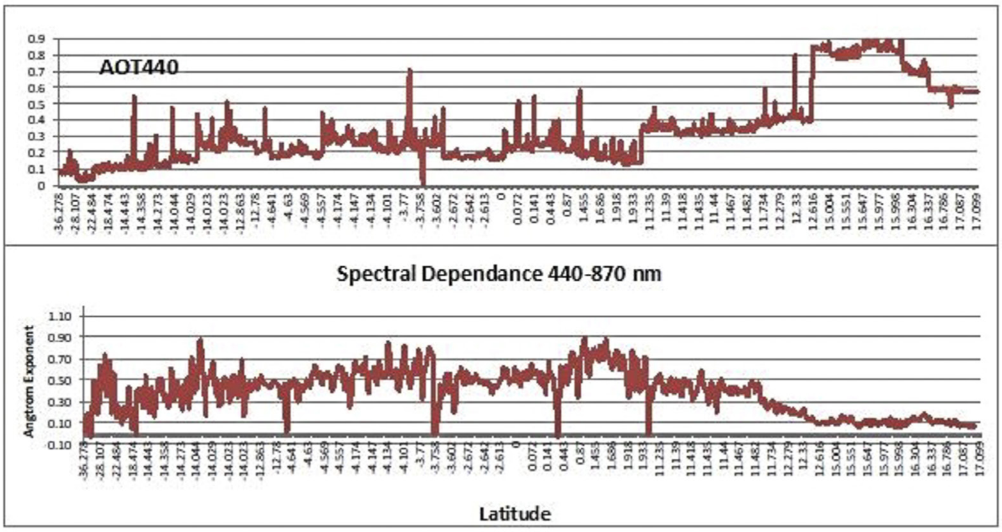

Fig. 7.3: Top figure is the Aerosol Optical Depth at 440 nm (a proxy of aerosol concentration) and the spectral dependence of the AOD between 440 and 870 nm (also known as Ångstrom Exponent and it is used to identify dust from other aerosol types).

Between 14 S and 10N, air masses originate from Africa with mixtures of clean air from the South Atlantic. African air may contain smoke as it was apparent in the satellite pictures. The AE is very fluctuating, a consequence of the low aerosol loadings (AOD<0.2) which result in a low signal from which the spectral dependence can be computed.

However, starting in 11N until the end of the series (17N), the AE has a fairly steady decline and stabilizing at 0.1. In the same latitude range, the AOD remained very high with values ~ 0.3 (2019-06-16) to ~0.9 (2019-06-17). Both the high AOD and very low AE are typical signatures of a dust outbreak as it was clearly recognized visually and by satellite imagery.

Overall this dataset of observations looks very promising as it captured a number of typical air masses and the number of observations are abundant. Further analysis of the dataset along with satellite and trajectory modeling may result in additional insights on the origin of the aerosols encountered during the PS120.

Data management

Microtops data will be stored in World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).at the AWI and additionally published via AERONET. The AERONET (AErosol RObotic NETwork) project is a federation of ground-based remote sensing aerosol networks established by NASA and PHOTONS (PHOtométrie pour le Traitement Opérationnel de Normalisation Satellitaire; Univ. of Lille 1, CNES, and CNRS-INSU) and is greatly expanded by networks (e.g., RIMA, AeroSpan, AEROCAN, and CARSNET) and collaborators from national agencies, institutes, universities, individual scientists, and partners.

8. ACKNOWLEDGEMENTS AND DEDICATIONS

Karen H. Wiltshire, Eva-Maria Brodte AWI

Dedication

The authors and the participants of the PS120 expedition would like to dedicate this expedition report to Dr. Mirco Scharfe, our beloved colleague. This *Polarstern* expedition was the first and last for Mirco. He passed away suddenly and unexpected a few weeks after our cruise. The scholars and lectures highly appreciated him, not alone for his teaching and scientific skills but for his personality. We all will remember him as a generous and genuine person, a caring teacher and an enthusiastic scientist.

Acknowledgement

The authors would like to express their deepest thanks and appreciation to the supporting and funding bodies of this expedition. These are the Alfred Wegener Institute Helmholtz-Centre for Polar- and Marine Research, Nippon Foundation (NF), the Partnership for Observation of the Global Ocean (POGO), the OCEAN TRAINING PORTAL (OTP), REKLIM, and ATLANTOS (European Union's Horizon 2020 research and innovation programme under grant agreement No 633211) for support and financing. We would like to thank PORTWIMS (Portugal Twinning for innovation and excellence in marine science and Earth observation) which partially funded the participation of Mara Gomes and Eberhard Sauter by the European Union's Horizon 2020 research and innovation programme under grant agreement nº 810139. An international training in this magnitude would not be possible without these strong and reliable networks. We are more than grateful for this dedication.

We would like to thank the NF-POGO Centre of Excellence, Helmholtz-Zentrum Geesthacht (HZG), Freie Universität Berlin (FUB), the National Aeronautic Space Agency (NASA), the Marine and Environmental Centre (MARE-ULisbon), National University of Ireland Galway (NUIG), the Irish Centre for Applied research in Geoscience (iCRAG) and the Deutsche Welle for their support by providing knowledge, instrumentation and faculty members. We thank colleagues who supported us land based and thus enabled this expedition.

We want to express special thanks to the captain and the crew for supporting and actively promoting the shipboard training as an important visible international capacity development programme. The scholars and teachers were highly impressed by the professionalism and the welcoming atmosphere on board.

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP’S CREW

A.4 STATION LIST

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AAU	Aarlborg University Fredrik Bajers Vej 5 9100 Aalborg Denmark
AU	Aarhus University Nordre Ringgade 1 8000 Aarhus C Denmark
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
DW	Deutsche Welle 53110 Bonn Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
UMD	Earth System Science Interdisciplinary Center (ESSIC) 5825 University Research Court, Suite 4001 College Park, MD 20740-3823 USA
FU-Berlin	Frei Universität Berlin Kaiserswerther Str. 16/18 14195 Berlin Germany
HUINAY	Huinay Scientific Field Station, Chilean Patagonia Huinay Hualaihué, Los Lagos Chile
IRB	Ruđer Bošković Institute Bijenička cesta 54, 10000 Zagreb Croatia

	Address
INSMET	Instituto de Meteorología de Cuba Carretera del Asilo 17032 Havana Cuba
MARE-FCUL	MARE-FCUL Edifício do Patronato Rua da Matemática, 49 3004-517 Coimbra Portugal
MARUM	Universität Bremen MARUM/ Institute of Environmental Physics (IUP) Otto-Hahn-Allee 1 28359 Bremen Germany
MPIMM	Max-Planck-Institut für Marine Mikrobiologie Celsiusstr. 1 D-28359 Bremen Germany
NUI	National University of Ireland, Galway, University Road, Galway Ireland
ODU	Old Dominion University 5115 Hampton Boulevard 23529 Norfolk USA
PANDATA	Pandata GmbH, Schwedter Straße 13, 10119 Berlin Germany
PML	Partnership for Observation of the Global Oceans (POGO) Plymouth Marine Laboratory, Prospect Place PL13DH Plymouth United Kingdom
Sakarya	Institute of Natural Sciences, Sakarya University Kampüs Street, 208 54050 Sakarya Turkey
SVNIT	Sardar Vallabhbhai National Institute of Technology, Ichchhanath 395007 Surat India

	Address
UB	Universitat de Barcelona Gran Via de les Corts Catalanes, 585 8007 Barcelona Spain
UBA	University of Buenos Aires Intendente Güiraldes 2160 Ciudad Universitaria C1428EGA Ciudad Autónoma de Buenos Aires Argentinia
UC	Pontificia Universidad Católica de Chile Avda. Libertador Bernardo O'Higgins 340 Santiago Chile
UCT	University of Cape Town Private Bag X3 7701 Rondebosch Republic of South Africa
UG	University Of Ghana, Marine and Fisheries Science Department GA-490-0243 Mafs Box Lg 99 Legon 233 Accra Ghana
UNEP-NAIROBI	UNEP U N HQ, Nyamaiya United Nations Ave, West Mugirango, Nairobi Kenia
UNI-HAIFA	Leon H. Charney School of Marine Sciences, University of Haifa, Abba Khoushy Ave 199 3498838 Haifa Israel
UKZN	University of KwaZulu-Natal Westville University Road, Westville 4000 Durban Republic of South Africa
ULISBOA	Universidad Lisboa Fciencias.id - Associacao Para A Investigacao E Desenvolvimento De Ciencias Edificio C1, Piso 3 1749 016 LISBON Portugal

	Address
UMAG	Universidad de Magallanes, Instituto de La Patagonia Avenida Manuel Bulnes 01855Antarctic Dome 6210427 Punta Arenas Chile
UNESP	UNESP Universidade Estadual Paulista, Praça Infante Dom Henrique, s/n 11330-900 São Vicente Brazil
Uniandes	Universidad de Los Andes Cra 1 18a 12 111711 Bogotá Columbia
Uni Heidelberg	Universität Heidelberg Grabengasse 1 69117 Heidelberg Germany
UOM	Department of Biosciences and Ocean Studies, Faculty of Science, University of Mauritius 80837 Reduit Mauritius
UP	University of the Philippines 1 Velasquez Street, UP Diliman Campus 1101 Quezon City Philippines
Utrecht University	Utrecht University Princetonplein 3583 CC Utrecht The Netherlands

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Leg 1

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Vega	Ximena	UMAG	Student	Oceanography
Al-Najjar	Hassan	Sakarya	Student	Oceanography
Aravind	Anjana	SVNIT	Student	Oceanography
Ballyram	Stacy	HUINAY	Student	Oceanography
Brempong	Emmanuel K.	UG	Student	Oceanography
Carstens	Kristine	AWI	Technican	Oceanography
Croot	Peter	NUI	Scientist	Oceanography
de la Maza	Lucas	UC	Student	Oceanography
Dreutter	Simon	AWI	Scientist	Bathymetry
Eifried	Markus	DWD	Scientist	Meterology
El Kassar	Jan	FU-Berlin	Scientist	Remote Sensing
Eschenröder	Julian	AWI	Student	Oceanography
Farias Pardo	Juan Carlos	UNESP	Student	Oceanography
Gassó	Santiago	UMD	Scientist	Remote Sensing
Go	Gay Amabelle	UP	Student	Oceanography
Gomez	Mara	ULISBOA	Scientist	Oceanography
Gregory	Clynton	NUI	Scientist	Oceanography
Hartmann	Jan	AWI	Scientist	Oceanography
Heins	Anneke	MPIMM	Scientist	Oceanography
Hempelt	Juliane	DWD	Technican	Meterology
Ishaque	Marufa	ODU	Student	Oceanography
Karpouzoglou	Thodoris	Utrecht University	Student	Oceanography
Keck	Therese	PANDATA	Scientist	Remote Sensing
Kilcoyne	Emma	NUI	Student	Oceanography
Kirstein	Inga	AAU	Scientist	Oceanography
Kohlberg	Eberhard	AWI	Scientist	Medical Advisor
Krägefsky	Sören	AWI	Scientist	Oceanography
Krug	Lilian	PML	Scientist	Oceanography
Lantovololona	Felaniaina	PECHE	Student	Oceanography
Lemke	Peter	AWI	Scientist	Physics
Lesic	Nina-Marie	AWI	Student	Bathymetry
Louis	Yohan Louis	UOM	Student	Oceanography
Mohamed	Ahmad Hussein	UNEP-NAIROBI	Student	Oceanography
Naidoo	Merrisa	UKZN	Student	Oceanography
Neira-Ramírez	Lorena	Uniandes	Student	Oceanography
Orlic	Sandi	IRBI	Scientist	Oceanography

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Palomino Gaviria	Angela Patricia	UB	Student	Oceanography
Peña Ramirez	Graciela Stefani	UBA	Student	Oceanography
Povea Pérez	Yoania	INSMET	Student	Oceanography
Raeke	Andreas	DWD	Scientist	Meterology
Ramon	Debra	UNI-HAIFA	Student	Oceanography
Sauter	Eberhard	AWI	Scientist	Oceanography
Scharfe	Mirco	AWI	Scientist	Oceanography
Scholz	Vincent Valentin	AU	Student	Oceanography
Seymour	Sian	UCT	Student	Oceanography
Shigihara Lima	Luciana	INPE	Student	Oceanography
Wiltshire	Karen Helen	AWI	Scientist	Oceanography

Leg 2

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Vega	Ximena	UMAG	Student	Oceanography
Al-Najjar	Hassan	Sakarya	Student	Oceanography
Aravind	Anjana	SVNIT	Student	Oceanography
Ballyram	Stacy	HUINAY	Student	Oceanography
Brempong	Emmanuel K.	UG	Student	Oceanography
Brodte	Eva-Maria	AWI	Scientist	Oceanography
Carstens	Kristine	AWI	Technican	Oceanography
Croot	Peter	NUI	Scientist	Oceanography
de la Maza	Lucas	UC	Student	Oceanography
Eifried	Markus	DWD	Scientist	Meterology
El Kassar	Jan	FU-Berlin	Scientist	Remote Sensing
Eschenröder	Julian	AWI	Student	Oceanography
Farias Pardo	Juan Carlos	UNESP	Student	Oceanography
Gassó	Santiago	UMD	Scientist	Remote Sensing
Gerchow	Peter	AWI	Technican	Oceanography
Go	Gay Amabelle	UP	Student	Oceanography
Gomez	Mara	ULISBOA	Scientist	Oceanography
Gregory	Clynton	NUI	Scientist	Oceanography
Hartmann	Jan	AWI	Scientist	Oceanography
Heins	Anneke	MPIMM	Scientist	Oceanography
Hempelt	Juliane	DWD	Technican	Meterology
Immerz	Antonia	AWI	Technican	IT

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung / Discipline**
Ishaque	Marufa	ODU	Student	Oceanography
Karpouzoglou	Thodoris	Utrecht University	Student	Oceanography
Keck	Therese	PANDATA	Scientist	Remote Sensing
Kilcoyne	Emma	NUI	Student	Oceanography
Kirstein	Inga	AAU	Scientist	Oceanography
Kohlberg	Eberhard	AWI	Scientist	Medical Advisor
Krug	Lilian	PML	Scientist	Oceanography
Lantovololona	Felaniaina	PECHE	Student	Oceanography
Lemke	Peter	AWI	Scientist	Physics
Louis	Yohan Louis	UOM	Student	Oceanography
Matthes	Jörg	AWI	Engineer	IT
Mohamed	Ahmad Hussein	UNEP-NAIROBI	Student	Oceanography
Naidoo	Merrisa	UKZN	Student	Oceanography
Neira-Ramírez	Lorena	Uniandes	Student	Oceanography
Palomino Gaviria	Angela Patricia	UB	Student	Oceanography
Peña Ramirez	Graciela Stefani	UBA	Student	Oceanography
Petri	Martin	AWI	Technican	IT
Povea Pérez	Yoania	INSMET	Student	Oceanography
Raeke	Andreas	DWD	Scientist	Meterology
Ramon	Debra	UNI-HAIFA	Student	Oceanography
Sauter	Eberhard	AWI	Scientist	Oceanography
Scharfe	Mirco	AWI	Scientist	Oceanography
Schauenberg	Tim	DW	journalist	Journalist
Scholz	Vincent Valentin	AU	Student	Oceanography
Seymour	Sian	UCT	Student	Oceanography
Shigihara Lima	Luciana	INPE	Student	Oceanography
Wiltshire	Karen Helen	AWI	Scientist	Oceanography

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
1	Langhinrichs, Moritz	Master
2	Lauber, Felix	1. Offc.
3	Grafe, Jens	Ch. Eng.
4	Hering, Igor	2. Offc.
5	Langer, Carl	2. Offc.
6	Neumann, Ralph Peter	3. Offc.
7	Heitland, Tim	Doctor
8	Kohlberg, Eberhard	Doctor
9	Christian, Boris	R. Offc.
10	Krinfeld, Oleksandr	2. Eng.
11	Haack, Michael	2. Eng.
12	Fiedler, Andreas	2. Eng.
13	Redmer, Jens Dirk	Elec. Eng.
14	Ganter, Armin	ELO
15	Hüttebräuker, Olaf	ELO
16	Nasis, Illias	ELO
17	Himmel, Frank	ELO
18	Brück, Sebastian	Boatsw.
19	Henning, Jörg	Carpenter
20	Bäcker, Andreas	A.B.
21	Möller, Falko	A.B.
22	Neubauer, Werner	A.B.
23	Decker, Jens	A.B.
24	Schade, Tom	A.B.
25	Wende, Uwe	A.B.
26	Klee, Philipp	A.B.
27	Buchholz, Joscha	A.B.
28	Köpnick, Ulrich	Storek.
29	Schwarz, Uwe	Mot-man
30	Preußner, Jörg	Mot-man

No.	Name	Rank
31	Freiwald, Petra	Mot-man
32	Teichert, Uwe	Mot-man
33	Gebhardt, Norman	Mot-man
34	Schnieder, Sven	Cook
35	Silinski, Frank	Cooksmate
36	Möller, Wolfgang	Cooksmate
37	Czyborra, Bärbel	1. Stwdess
38	Wöckener, Martina	Stwdess/N.
39	Dibenau, Torsten	2. Stwdess
40	Silinski, Carmen	2. Steward
41	Golla, Gerald	2. Stwdess
42	Arendt, Rene	2. Steward
43	Sun, Yongsheng	2. Stwdess
44	Chen, Dan Sheng	Laundrym.

A.4 STATIONSLISTE / STATION LIST

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-1	2019-06-03	11:28	-49.07504	-55.37827	1064	ADCP_150	station start	
PS120_0_ Underway-1	2019-06-03	11:28	-49.07444	-55.37774	1065	ADCP_150	profile start	
PS120_0_ Underway-1	2019-06-20	07:25	27.57030	-15.52150	NA	ADCP_150	profile end	
PS120_0_ Underway-1	2019-06-20	07:25	27.57030	-15.52150	NA	ADCP_150	station end	
PS120_0_ Underway-3	2019-06-03	12:19	-48.93678	-55.22401	1229	FBOX	station start	
PS120_0_ Underway-3	2019-06-03	12:21	-48.93012	-55.22020	1237	FBOX	profile start	
PS120_0_ Underway-3	2019-06-20	07:23	27.56739	-15.52541	NA	FBOX	profile end	
PS120_0_ Underway-3	2019-06-20	16:43	28.18970	-15.35402	NA	FBOX	profile start	
PS120_0_ Underway-3	2019-06-23	13:11	39.93110	-12.73729	5224	FBOX	profile end	
PS120_0_ Underway-3	2019-06-23	13:14	39.94052	-12.73467	5225	FBOX	station end	
PS120_0_ Underway-4	2019-06-03	11:35	-49.05309	-55.35927	1097	HVAIR	station start	
PS120_0_ Underway-4	2019-06-03	11:35	-49.05245	-55.35872	1098	HVAIR	profile start	
PS120_0_ Underway-4	2019-06-20	07:24	27.56996	-15.52196	NA	HVAIR	profile end	
PS120_0_ Underway-4	2019-06-20	16:42	28.18543	-15.35567	NA	HVAIR	profile start	
PS120_0_ Underway-4	2019-06-23	13:11	39.93110	-12.73729	5224	HVAIR	profile end	
PS120_0_ Underway-4	2019-06-23	13:15	39.94420	-12.73372	5225	HVAIR	station end	
PS120_0_ Underway-5	2019-06-03	12:19	-48.93818	-55.22484	1228	PCO2_GO	station start	
PS120_0_ Underway-5	2019-06-03	12:19	-48.93760	-55.22449	1228	PCO2_GO	profile start	
PS120_0_ Underway-5	2019-06-20	07:23	27.56776	-15.52491	NA	PCO2_GO	profile end	
PS120_0_ Underway-5	2019-06-20	16:43	28.18894	-15.35431	NA	PCO2_GO	profile start	
PS120_0_ Underway-5	2019-06-23	13:11	39.93110	-12.73729	5224	PCO2_GO	profile end	
PS120_0_ Underway-5	2019-06-23	13:14	39.94122	-12.73450	5225	PCO2_GO	station end	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-6	2019-06-03	12:18	-48.93946	-55.22561	1227	PCO2_ SUB	station start	
PS120_0_ Underway-6	2019-06-03	12:18	-48.93889	-55.22526	1228	PCO2_ SUB	profile start	
PS120_0_ Underway-6	2019-06-20	07:24	27.56845	-15.52397	NA	PCO2_ SUB	profile end	
PS120_0_ Underway-6	2019-06-20	16:43	28.18809	-15.35464	NA	PCO2_ SUB	profile start	
PS120_0_ Underway-6	2019-06-23	13:11	39.93110	-12.73729	5224	PCO2_ SUB	profile end	
PS120_0_ Underway-6	2019-06-23	13:14	39.94239	-12.73420	5226	PCO2_ SUB	station end	
PS120_0_ Underway-7	2019-06-03	11:35	-49.05172	-55.35809	1100	RM	station start	
PS120_0_ Underway-7	2019-06-03	11:35	-49.05107	-55.35754	1100	RM	profile start	
PS120_0_ Underway-7	2019-06-20	07:24	27.56954	-15.52251	NA	RM	profile end	
PS120_0_ Underway-7	2019-06-20	16:42	28.18607	-15.35542	NA	RM	profile start	
PS120_0_ Underway-7	2019-06-23	13:11	39.93110	-12.73729	5224	RM	profile end	
PS120_0_ Underway-7	2019-06-23	13:15	39.94354	-12.73390	5226	RM	station end	
PS120_0_ Underway-8	2019-06-03	12:16	-48.94561	-55.22917	1222	GRAV	station start	
PS120_0_ Underway-8	2019-06-03	12:17	-48.94490	-55.22876	1222	GRAV	profile start	
PS120_0_ Underway-8	2019-06-20	07:24	27.56885	-15.52343	NA	GRAV	profile end	
PS120_0_ Underway-8	2019-06-20	16:42	28.18724	-15.35496	NA	GRAV	profile start	
PS120_0_ Underway-8	2019-06-23	13:11	39.93111	-12.73728	5224	GRAV	profile end	
PS120_0_ Underway-8	2019-06-23	13:15	39.94296	-12.73405	5226	GRAV	station end	
PS120_0_ Underway-9	2019-06-03	11:33	-49.05729	-55.36292	1090	SVP	station start	
PS120_0_ Underway-9	2019-06-03	11:34	-49.05664	-55.36238	1091	SVP	profile start	
PS120_0_ Underway-9	2019-06-20	07:25	27.57098	-15.52060	NA	SVP	profile end	
PS120_0_ Underway-9	2019-06-20	16:42	28.18464	-15.35598	NA	SVP	profile start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-9	2019-06-23	13:11	39.93111	-12.73728	5224	SVP	profile end	
PS120_0_ Underway-9	2019-06-23	13:15	39.94530	-12.73342	5225	SVP	station end	
PS120_0_ Underway-10	2019-06-03	11:29	-49.07098	-55.37474	1069	TSG_ KEEL	station start	
PS120_0_ Underway-10	2019-06-03	11:29	-49.07024	-55.37412	1070	TSG_ KEEL	profile start	
PS120_0_ Underway-10	2019-06-20	07:25	27.57058	-15.52113	NA	TSG_ KEEL	profile end	
PS120_0_ Underway-10	2019-06-20	16:47	28.20521	-15.34818	NA	TSG_ KEEL	profile start	
PS120_0_ Underway-10	2019-06-23	13:11	39.93111	-12.73728	5224	TSG_ KEEL	profile end	
PS120_0_ Underway-10	2019-06-23	13:16	39.94622	-12.73316	5225	TSG_ KEEL	station end	
PS120_0_ Underway-11	2019-06-03	11:30	-49.06910	-55.37312	1072	TSG_ KEEL_2	station start	
PS120_0_ Underway-11	2019-06-03	11:30	-49.06846	-55.37256	1073	TSG_ KEEL_2	profile start	
PS120_0_ Underway-11	2019-06-20	07:26	27.57411	-15.51635	NA	TSG_ KEEL_2	profile end	
PS120_0_ Underway-11	2019-06-20	16:39	28.17592	-15.35946	NA	TSG_ KEEL_2	profile start	
PS120_0_ Underway-11	2019-06-23	13:11	39.93111	-12.73728	5224	TSG_ KEEL_2	profile end	
PS120_0_ Underway-11	2019-06-23	13:16	39.94574	-12.73330	5225	TSG_ KEEL_2	station end	
PS120_0_ Underway-12	2019-06-02	16:00	-51.66705	-57.77132	NA	WST	station start	
PS120_0_ Underway-12	2019-06-02	16:00	-51.66705	-57.77132	NA	WST	profile start	
PS120_0_ Underway-12	2019-06-23	13:11	39.93111	-12.73728	5224	WST	profile end	
PS120_0_ Underway-12	2019-06-23	13:16	39.94673	-12.73301	5225	WST	station end	
PS120_0_ Underway-13	2019-06-03	12:22	-48.92743	-55.21858	1242	MAG	station start	
PS120_0_ Underway-13	2019-06-03	12:22	-48.92688	-55.21823	1243	MAG	profile start	
PS120_0_ Underway-13	2019-06-20	07:23	27.56678	-15.52622	NA	MAG	profile end	
PS120_0_ Underway-13	2019-06-20	16:43	28.19079	-15.35361	NA	MAG	profile start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-13	2019-06-23	13:11	39.93111	-12.73728	5224	MAG	profile end	
PS120_0_ Underway-13	2019-06-23	13:14	39.93964	-12.73490	5225	MAG	station end	
PS120_0_ Underway-14	2019-06-03	12:25	-48.91759	-55.21283	1260	HS	station start	
PS120_0_ Underway-14	2019-06-03	12:25	-48.91681	-55.21236	1261	HS	profile start	
PS120_0_ Underway-14	2019-06-19	16:38	25.96046	-18.31546	3363	HS	profile end	
PS120_0_ Underway-14	2019-06-19	16:39	25.96122	-18.31416	3366	HS	station end	
PS120_0_ Underway-15	2019-06-03	13:23	-48.72950	-55.08082	1774	PS	station start	
PS120_0_ Underway-15	2019-06-03	13:23	-48.72877	-55.08020	1781	PS	profile start	
PS120_0_ Underway-15	2019-06-19	16:38	25.95941	-18.31722	3363	PS	profile end	
PS120_0_ Underway-15	2019-06-19	16:38	25.95999	-18.31623	3364	PS	station end	
PS120_0_ Underway-16	2019-06-24	13:57	43.77627	-11.42276	4968	ADCP	station start	
PS120_0_ Underway-16	2019-06-24	13:58	43.77820	-11.42139	4968	ADCP	profile start	
PS120_0_ Underway-16	2019-06-28	12:33	54.08361	7.96716	21,2	ADCP	profile end	
PS120_0_ Underway-16	2019-06-28	12:33	54.08362	7.96705	21,2	ADCP	station end	
PS120_0_ Underway-17	2019-06-24	13:57	43.77627	-11.42276	4968	FBOX	station start	
PS120_0_ Underway-17	2019-06-24	13:58	43.77883	-11.42095	4968	FBOX	profile start	
PS120_0_ Underway-17	2019-06-28	12:35	54.08431	7.96556	21,4	FBOX	profile end	
PS120_0_ Underway-17	2019-06-28	12:36	54.08447	7.96520	21,4	FBOX	station end	
PS120_0_ Underway-18	2019-06-24	13:57	43.77627	-11.42276	4968	PCO2_GO	station start	
PS120_0_ Underway-18	2019-06-24	13:59	43.77952	-11.42048	4968	PCO2_GO	profile start	
PS120_0_ Underway-18	2019-06-28	12:34	54.08378	7.96654	21,1	PCO2_GO	profile end	
PS120_0_ Underway-18	2019-06-28	12:35	54.08390	7.96634	21,5	PCO2_GO	station end	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-20	2019-06-24	13:57	43.77627	-11.42276	4968	TSG_ KEEL	station start	
PS120_0_ Underway-20	2019-06-24	13:59	43.78061	-11.41976	4968	TSG_ KEEL	profile start	
PS120_0_ Underway-20	2019-06-28	12:34	54.08366	7.96678	21	TSG_ KEEL	profile end	
PS120_0_ Underway-20	2019-06-28	12:34	54.08370	7.96667	21,3	TSG_ KEEL	station end	
PS120_0_ Underway-21	2019-06-24	13:57	43.77627	-11.42276	4968	TSG_ KEEL_2	station start	
PS120_0_ Underway-21	2019-06-24	13:59	43.78118	-11.41940	4968	TSG_ KEEL_2	profile start	
PS120_0_ Underway-21	2019-06-28	12:37	54.08505	7.96246	21,7	TSG_ KEEL_2	profile end	
PS120_0_ Underway-21	2019-06-28	12:37	54.08500	7.96090	22,1	TSG_ KEEL_2	station end	
PS120_0_ Underway-22	2019-06-24	13:57	43.77627	-11.42276	4968	SVP	station start	
PS120_0_ Underway-22	2019-06-24	13:59	43.78165	-11.41910	4968	SVP	profile start	
PS120_0_ Underway-22	2019-06-28	12:35	54.08400	7.96617	21,2	SVP	profile end	
PS120_0_ Underway-22	2019-06-28	12:35	54.08412	7.96596	21,3	SVP	station end	
PS120_0_ Underway-23	2019-06-24	13:57	43.77627	-11.42276	4968	WST	station start	
PS120_0_ Underway-23	2019-06-24	14:00	43.78234	-11.41867	4968	WST	profile start	
PS120_0_ Underway-24	2019-06-24	13:57	43.77627	-11.42276	4968	HVAIR	station start	
PS120_0_ Underway-24	2019-06-24	14:13	43.82104	-11.39373	4968	HVAIR	profile start	
PS120_0_ Underway-24	2019-06-28	12:33	54.08363	7.96697	21,2	HVAIR	profile end	
PS120_0_ Underway-24	2019-06-28	12:34	54.08363	7.96687	21,2	HVAIR	station end	
PS120_0_ Underway-25	2019-06-24	13:57	43.77627	-11.42276	4968	GRAV	station start	
PS120_0_ Underway-25	2019-06-24	14:00	43.78401	-11.41765	4969	GRAV	profile start	
PS120_0_ Underway-25	2019-06-28	12:37	54.08492	7.96019	21,9	GRAV	profile end	
PS120_0_ Underway-25	2019-06-28	12:37	54.08483	7.95953	22	GRAV	station end	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_0_ Underway-26	2019-06-24	13:57	43.77627	-11.42276	4968	MAG	station start	
PS120_0_ Underway-26	2019-06-24	14:01	43.78577	-11.41654	4968	MAG	profile start	
PS120_0_ Underway-26	2019-06-28	12:36	54.08462	7.96477	21,4	MAG	profile end	
PS120_0_ Underway-26	2019-06-28	12:36	54.08477	7.96427	21,6	MAG	station end	
PS120_0_ Underway-27	2019-06-24	13:57	43.77627	-11.42276	4968	RM	station start	
PS120_0_ Underway-27	2019-06-24	14:00	43.78486	-11.41712	4968	RM	profile start	
PS120_0_ Underway-27	2019-06-28	12:36	54.08489	7.96376	21,6	RM	profile end	
PS120_0_ Underway-27	2019-06-28	12:36	54.08499	7.96315	21,6	RM	station end	
PS120_0_ Underway-28	2019-06-24	13:57	43.77625	-11.42277	4968	PCO2_ SUB	station start	
PS120_0_ Underway-28	2019-06-24	13:59	43.77935	-11.42059	4968	PCO2_ SUB	profile start	
PS120_0_ Underway-28	2019-06-28	12:38	54.08470	7.95876	22,1	PCO2_ SUB	profile end	
PS120_0_ Underway-28	2019-06-28	12:38	54.08459	7.95807	22	PCO2_ SUB	station end	
PS120_1-1	2019-06-03	17:15	-48.00197	-54.45213	5893	FLOAT	station start	
PS120_1-1	2019-06-03	17:16	-47.99934	-54.44963	5893	FLOAT	station end	
PS120_1-2	2019-06-03	17:20	-47.99342	-54.44291	5881	XBT	station start	
PS120_1-2	2019-06-03	17:28	-47.98217	-54.43523	5873	XBT	at depth	
PS120_1-2	2019-06-03	17:28	-47.98110	-54.43432	5866	XBT	station end	
PS120_1-3	2019-06-03	17:28	-47.98103	-54.43426	5864	BUCKET	station start	
PS120_1-3	2019-06-03	17:31	-47.97572	-54.42969	5860	BUCKET	station end	
PS120_2-1	2019-06-04	03:55	-46.05131	-52.49564	6050	FLOAT	station start	
PS120_2-1	2019-06-04	04:14	-46.00230	-52.45293	6044	FLOAT	station end	
PS120_2-2	2019-06-04	04:15	-45.99994	-52.45526	6045	XBT	station start	
PS120_2-2	2019-06-04	04:23	-45.99064	-52.46853	6046	XBT	at depth	
PS120_2-2	2019-06-04	04:23	-45.99010	-52.46929	6045	XBT	station end	
PS120_3-1	2019-06-04	11:01	-44.80585	-51.27917	5832	CTDOZE	station start	
PS120_3-1	2019-06-04	13:05	-44.80539	-51.27939	5830	CTDOZE	at depth	
PS120_3-1	2019-06-04	15:26	-44.80554	-51.27948	5829	CTDOZE	station end	
PS120_3-2	2019-06-04	15:27	-44.80554	-51.27958	5831	PLA	station start	
PS120_3-2	2019-06-04	15:47	-44.80540	-51.27974	5828	PLA	at depth	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_3-2	2019-06-04	16:00	-44.80526	-51.27953	5830	PLA	station end	
PS120_3-3	2019-06-04	15:51	-44.80548	-51.27957	5831	BUCKET	station start	
PS120_3-3	2019-06-04	15:56	-44.80560	-51.27959	5827	BUCKET	station end	
PS120_4-1	2019-06-05	06:26	-42.07601	-48.68766	5614	XBT	station start	
PS120_4-1	2019-06-05	06:33	-42.06639	-48.68524	5614	XBT	at depth	
PS120_4-1	2019-06-05	06:33	-42.06637	-48.68525	5614	XBT	station end	
PS120_4-2	2019-06-05	06:33	-42.06629	-48.68528	5614	BUCKET	station start	
PS120_4-2	2019-06-05	06:36	-42.06112	-48.68691	5616	BUCKET	station end	
PS120_5-1	2019-06-05	14:30	-40.50124	-47.25133	5235	PLA	station start	
PS120_5-1	2019-06-05	14:43	-40.50058	-47.24598	5234	PLA	at depth	
PS120_5-1	2019-06-05	14:55	-40.50166	-47.25302	5239	PLA	station end	
PS120_5-2	2019-06-05	14:35	-40.50094	-47.24864	5233	BUCKET	station start	
PS120_5-2	2019-06-05	14:37	-40.50091	-47.24780	5234	BUCKET	station end	
PS120_5-2	2019-06-05	14:37	-40.50093	-47.24757	5235	BUCKET	station start	
PS120_5-2	2019-06-05	14:39	-40.50091	-47.24713	5235	BUCKET	station end	
PS120_5-3	2019-06-05	15:00	-40.50120	-47.25384	5236	CTDOZE	station start	
PS120_5-3	2019-06-05	16:49	-40.50037	-47.24603	5236	CTDOZE	at depth	
PS120_5-3	2019-06-05	18:40	-40.50491	-47.23906	5233	CTDOZE	station end	
PS120_6-1	2019-06-06	15:05	-36.52829	-43.74633	4948	XBT	station start	
PS120_6-1	2019-06-06	15:22	-36.49552	-43.73287	4939	XBT	at depth	
PS120_6-1	2019-06-06	15:22	-36.49550	-43.73290	4939	XBT	station end	
PS120_6-2	2019-06-06	15:18	-36.50158	-43.72661	4943	BUCKET	station start	
PS120_6-2	2019-06-06	15:20	-36.49822	-43.73001	4950	BUCKET	station end	
PS120_7-1	2019-06-07	15:36	-32.01652	-39.97896	4047	FLOAT	station start	
PS120_7-1	2019-06-07	15:42	-32.00648	-39.97200	4048	FLOAT	station end	
PS120_7-2	2019-06-07	15:43	-32.00388	-39.97267	4046	XBT	station start	
PS120_7-2	2019-06-07	15:48	-31.99605	-39.97447	4025	XBT	at depth	
PS120_7-2	2019-06-07	15:50	-31.99239	-39.97541	4018	XBT	station end	
PS120_7-3	2019-06-07	15:45	-32.00067	-39.97330	4036	BUCKET	station start	
PS120_7-3	2019-06-07	15:48	-31.99655	-39.97434	4030	BUCKET	station end	
PS120_8-1	2019-06-07	20:12	-31.19791	-39.32109	4499	PLA	station start	
PS120_8-1	2019-06-07	20:23	-31.19874	-39.32180	4500	PLA	at depth	
PS120_8-1	2019-06-07	20:28	-31.19894	-39.32220	4503	PLA	station end	
PS120_8-2	2019-06-07	20:18	-31.19847	-39.32160	4498	BUCKET	station start	
PS120_8-2	2019-06-07	20:21	-31.19864	-39.32171	4501	BUCKET	station end	
PS120_8-3	2019-06-07	20:30	-31.19899	-39.32234	4506	CTDOZE	station start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_8-3	2019-06-07	22:07	-31.19981	-39.32380	4515	CTDOZE	at depth	
PS120_8-3	2019-06-07	23:46	-31.19922	-39.32130	4503	CTDOZE	station end	
PS120_9-1	2019-06-08	20:25	-26.99967	-37.04966	4605	XBT	station start	
PS120_9-1	2019-06-08	20:32	-26.98946	-37.04476	4601	XBT	at depth	
PS120_9-1	2019-06-08	20:32	-26.98903	-37.04455	4604	XBT	station end	
PS120_9-2	2019-06-08	20:26	-26.99800	-37.04888	4609	BUCKET	station start	
PS120_9-2	2019-06-08	20:28	-26.99540	-37.04766	4606	BUCKET	station end	
PS120_10-1	2019-06-09	19:55	-22.01218	-34.71276	4525	FLOAT	station start	
PS120_10-1	2019-06-09	19:57	-22.00967	-34.71172	4525	FLOAT	station end	
PS120_10-2	2019-06-09	19:57	-22.00941	-34.71161	4525	XBT	station start	
PS120_10-2	2019-06-09	20:00	-22.00332	-34.70907	4524	XBT	at depth	
PS120_10-2	2019-06-09	20:01	-22.00288	-34.70890	4524	XBT	station end	
PS120_10-3	2019-06-09	19:57	-22.00915	-34.71151	4527	BUCKET	station start	
PS120_10-3	2019-06-09	20:03	-21.99925	-34.70737	4526	BUCKET	station end	
PS120_11-1	2019-06-10	10:01	-18.99894	-33.43096	4250	PLA	station start	
PS120_11-1	2019-06-10	10:11	-18.99856	-33.43128	4249	PLA	at depth	
PS120_11-1	2019-06-10	10:15	-18.99912	-33.43122	4253	PLA	station end	
PS120_11-2	2019-06-10	10:05	-18.99861	-33.43112	4250	BUCKET	station start	
PS120_11-2	2019-06-10	10:09	-18.99849	-33.43129	4253	BUCKET	station end	
PS120_11-3	2019-06-10	10:22	-18.99992	-33.43037	4254	CTDOZE	station start	
PS120_11-3	2019-06-10	10:52	-19.00011	-33.43068	4250	CTDOZE	at depth	
PS120_11-3	2019-06-10	11:28	-18.99903	-33.43058	4249	CTDOZE	station end	
PS120_12-1	2019-06-11	06:28	-15.00607	-31.73231	4718	XBT	station start	
PS120_12-1	2019-06-11	06:38	-14.99209	-31.72625	4720	XBT	station end	
PS120_12-2	2019-06-11	06:29	-15.00486	-31.73183	4715	BUCKET	station start	
PS120_12-2	2019-06-11	06:35	-14.99656	-31.72815	4723	BUCKET	station end	
PS120_13-1	2019-06-12	06:57	-10.00034	-29.64730	5153	XBT	station start	
PS120_13-1	2019-06-12	07:06	-9.98950	-29.64277	5235	XBT	station end	
PS120_13-2	2019-06-12	06:57	-9.99999	-29.64715	5159	BUCKET	station start	
PS120_13-2	2019-06-12	07:01	-9.99455	-29.64494	5185	BUCKET	station end	
PS120_14-1	2019-06-13	06:49	-5.00915	-27.60100	5510	FLOAT	station start	
PS120_14-1	2019-06-13	06:49	-5.00793	-27.60049	5522	FLOAT	station end	
PS120_14-2	2019-06-13	06:50	-5.00750	-27.60030	5517	XBT	station start	
PS120_14-2	2019-06-13	06:57	-4.99826	-27.59633	5499	XBT	at depth	
PS120_14-2	2019-06-13	06:57	-4.99770	-27.59608	5519	XBT	station end	
PS120_14-3	2019-06-13	06:51	-5.00565	-27.59947	5518	BUCKET	station start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_14-3	2019-06-13	06:55	-5.00033	-27.59721	5517	BUCKET	station end	
PS120_15-1	2019-06-14	06:45	-0.00064	-25.59733	3343	PLA	station start	
PS120_15-1	2019-06-14	06:53	-0.00025	-25.59792	3330	PLA	at depth	
PS120_15-1	2019-06-14	06:58	-0.00016	-25.59777	3337	PLA	station end	
PS120_15-2	2019-06-14	06:46	-0.00057	-25.59756	3338	BUCKET	station start	
PS120_15-2	2019-06-14	06:51	-0.00033	-25.59792	3329	BUCKET	station end	
PS120_15-3	2019-06-14	06:59	-0.00016	-25.59776	3336	CTDOZE	station start	
PS120_15-3	2019-06-14	08:24	-0.00006	-25.59570	3335	CTDOZE	at depth	
PS120_15-3	2019-06-14	09:48	0.00093	-25.59528	3334	CTDOZE	station end	
PS120_16-1	2019-06-15	22:09	7.99921	-23.52230	4489	XBT	station start	
PS120_16-1	2019-06-15	22:15	8.00884	-23.51964	4483	XBT	at depth	
PS120_16-1	2019-06-15	22:15	8.00886	-23.51963	4483	XBT	station end	
PS120_16-2	2019-06-15	22:09	7.99942	-23.52227	4489	BUCKET	station start	
PS120_16-2	2019-06-15	22:13	8.00565	-23.52065	4493	BUCKET	station end	
PS120_17-1	2019-06-17	06:12	14.99997	-21.98652	4698	PLA	station start	
PS120_17-1	2019-06-17	06:20	15.00048	-21.98736	4047	PLA	at depth	
PS120_17-1	2019-06-17	06:24	15.00028	-21.98780	4046	PLA	station end	
PS120_17-2	2019-06-17	06:15	15.00032	-21.98682	4046	BUCKET	station start	
PS120_17-2	2019-06-17	06:18	15.00050	-21.98716	4045	BUCKET	station end	
PS120_17-3	2019-06-17	06:25	15.00023	-21.98786	4049	CTDOZE	station start	
PS120_17-3	2019-06-17	07:52	15.00085	-21.98984	4042	CTDOZE	at depth	
PS120_17-3	2019-06-17	09:37	15.00180	-21.98975	4048	CTDOZE	station end	
PS120_18-1	2019-06-18	18:26	22.00491	-20.68354	4237	XBT	station start	
PS120_18-1	2019-06-18	18:28	22.00815	-20.68266	4240	XBT	at depth	1000 m
PS120_18-1	2019-06-18	18:31	22.01140	-20.68178	4238	XBT	at depth	1800 m
PS120_18-1	2019-06-18	18:34	22.01529	-20.68072	4241	XBT	station end	
PS120_18-2	2019-06-18	18:26	22.00512	-20.68348	4236	BUCKET	station start	
PS120_18-2	2019-06-18	18:30	22.01025	-20.68209	4236	BUCKET	station end	
PS120_19-1	2019-06-19	10:17	25.33561	-19.39340	340	PLA	station start	
PS120_19-1	2019-06-19	10:25	25.33579	-19.39224	340	PLA	at depth	
PS120_19-1	2019-06-19	10:30	25.33573	-19.39201	340	PLA	station end	
PS120_19-2	2019-06-19	10:19	25.33576	-19.39263	340	BUCKET	station start	
PS120_19-2	2019-06-19	10:24	25.33577	-19.39229	340	BUCKET	station end	
PS120_19-3	2019-06-19	10:37	25.33493	-19.39175	336	CTDOZE	station start	
PS120_19-3	2019-06-19	10:58	25.33599	-19.39051	339	CTDOZE	at depth	
PS120_19-3	2019-06-19	11:20	25.33701	-19.38891	338	CTDOZE	station end	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_20-1	2019-06-21	01:10	29.99927	-15.05031	3310	CTDOZE	station start	
PS120_20-1	2019-06-21	02:22	29.99989	-15.04991	3311	CTDOZE	at depth	
PS120_20-1	2019-06-21	03:42	30.00005	-15.04951	3311	CTDOZE	station end	
PS120_20-2	2019-06-21	03:43	30.00007	-15.04949	3312	PLA	station start	
PS120_20-2	2019-06-21	03:59	29.99915	-15.04965	3311	PLA	at depth	
PS120_20-2	2019-06-21	04:04	29.99895	-15.04976	3311	PLA	station end	
PS120_20-3	2019-06-21	03:54	29.99949	-15.04951	3311	BUCKET	station start	
PS120_20-3	2019-06-21	03:59	29.99917	-15.04964	3312	BUCKET	station end	
PS120_21-1	2019-06-22	09:10	35.49904	-13.99999	4702	PLA	station start	
PS120_21-1	2019-06-22	09:20	35.49959	-13.99914	4703	PLA	at depth	
PS120_21-1	2019-06-22	09:30	35.49976	-13.99935	4703	PLA	station end	
PS120_21-2	2019-06-22	08:57	35.48476	-13.99903	4701	BUCKET	station start	
PS120_21-2	2019-06-22	09:17	35.49951	-13.99926	4703	BUCKET	station end	
PS120_21-3	2019-06-22	09:34	35.50001	-13.99953	4703	CTDOZE	station start	
PS120_21-3	2019-06-22	11:30	35.50022	-14.00000	4702	CTDOZE	at depth	
PS120_21-3	2019-06-22	13:28	35.50019	-13.99919	4703	CTDOZE	station end	
PS120_22-1	2019-06-23	08:07	39.00532	-13.00259	3636	XBT	station start	
PS120_22-1	2019-06-23	08:13	39.01618	-12.99981	3644	XBT	at depth	
PS120_22-2	2019-06-23	08:08	39.00642	-13.00233	3635	BUCKET	station start	
PS120_22-2	2019-06-23	08:14	39.01726	-12.99944	3645	BUCKET	station end	
PS120_23-1	2019-06-23	22:50	41.76872	-12.19949	4928	XBT	station start	
PS120_23-1	2019-06-23	22:57	41.77978	-12.19517	4922	XBT	at depth	
PS120_23-1	2019-06-23	22:57	41.78017	-12.19505	4921	XBT	station end	
PS120_23-2	2019-06-23	22:51	41.76996	-12.19902	4929	BUCKET	station start	
PS120_23-2	2019-06-23	22:55	41.77577	-12.19654	4925	BUCKET	station end	
PS120_24-1	2019-06-24	08:16	43.49854	-11.59929	4982	PLA	station start	
PS120_24-1	2019-06-24	08:21	43.49809	-11.59888	4982	PLA	at depth	
PS120_24-1	2019-06-24	08:26	43.49812	-11.59858	4983	PLA	station end	
PS120_24-2	2019-06-24	08:16	43.49850	-11.59925	4982	BUCKET	station start	
PS120_24-2	2019-06-24	08:19	43.49828	-11.59906	4983	BUCKET	station end	
PS120_24-3	2019-06-24	08:26	43.49812	-11.59855	4983	CTDOZE	station start	
PS120_24-3	2019-06-24	10:13	43.49948	-11.59856	4982	CTDOZE	at depth	
PS120_24-3	2019-06-24	12:10	43.49853	-11.60143	4982	CTDOZE	station end	
PS120_25-1	2019-06-25	06:25	46.76366	-9.45024	4604	XBT	station start	
PS120_25-1	2019-06-25	06:39	46.78546	-9.43551	4373	XBT	station end	
PS120_25-2	2019-06-25	06:26	46.76647	-9.44816	4605	BUCKET	station start	

Station	Date	Time	Latitude	Longitude	Depth [m]	Gear	Action	Comment
PS120_25-2	2019-06-25	06:29	46.77050	-9.44557	4546	BUCKET	station end	
PS120_26-1	2019-06-25	13:49	47.99915	-8.60172	1188	PLA	station start	
PS120_26-1	2019-06-25	14:02	48.00010	-8.60296	1184	PLA	at depth	
PS120_26-1	2019-06-25	14:06	48.00020	-8.60291	1182	PLA	station end	
PS120_26-2	2019-06-25	13:55	47.99966	-8.60216	1189	BUCKET	station start	
PS120_26-2	2019-06-25	14:01	48.00001	-8.60295	1186	BUCKET	station end	
PS120_26-3	2019-06-25	14:07	48.00011	-8.60291	1182	CTDOZE	station start	
PS120_26-3	2019-06-25	14:45	47.99980	-8.60093	1175	CTDOZE	at depth	
PS120_26-3	2019-06-25	15:24	47.99929	-8.59964	1167	CTDOZE	station end	
PS120_27-1	2019-06-28	11:55	54.07242	7.97100	20,7	GC	station start	
PS120_27-1	2019-06-28	12:20	54.08351	7.96793	20,8	GC	at depth	
PS120_27-1	2019-06-28	12:39	54.08407	7.95452	22,4	GC	station end	

Gear abbreviations	**Gear**
ADCP	Acoustic Doppler Current Profiler
ADCP_150	ADCP 150kHz
AFIM	AutoFim
BUCKET	Bucket Water Sampling
CTDOZE	CTD AWI-OZE
FBOX	FerryBox
FLOAT	Float
GC	Gravity Corer, Schwerelot
GRAV	Sea Gravimeter
HS	Hydrosweep
HVAIR	High Volume Air Sampler
MAG	Magnetometer
PCO2_GO	pCO2 GO
PCO2_SUB	pCO2 Subctech
PLA	Plankton Recorder / Net
PS	Parasound
RM	Radiation Measurements
SVP	Sound Velocity Profiler
TSG_KEEL	Thermosalinograph Keel
TSG_KEEL_2	Thermosalinograph Keel 2
WST	Weatherstation
XBT	Expendable Bathythermograph

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