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Helmholtz-Zentrum für Ozeanforschung Kiel

RV POSEIDON Fahrtbericht / Cruise Report POS534

STEMM-CCS: Strategies for Environmental Monitoring of Marine Carbon Capture and Storage

Leg 1: Kiel (Germany) – Aberdeen (United Kingdom)
01.05. – 22.05.2019

Leg 2: Aberdeen (United Kingdom) – Bremerhaven (Germany)
23.05. – 29.05.2019

Berichte aus dem GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

Nr. 52 (N. Ser.)

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RV POSEIDON
Cruise Report POS 534

Leg 1

1 – 22 May 2019
(Kiel - Aberdeen)

Leg 2

23 – 29 May 2019

(Aberdeen - Bremerhaven)

Lead: Mark Schmidt

GEOMAR Helmholtz Centre for Ocean Research Kiel

This cruise has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 654462 STEMM-CCS.

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1 Summary

1.1 Summary in English

The HORIZON 2020 EU project: “Strategies for Environmental Monitoring of Marine Carbon Capture and Storage” STEMM-CCS aims to determine monitoring strategies for offshore CCS (https://www.stemm-ccs.eu/).

To apply new leak detection technology developed within the project a joined research campaign with RV Poseidon (POS534 cruise) and RRS James Cook was conducted in an area near the Goldeneye offshore platform. There a CO_2/tracer-release experiment was installed at the seafloor from onboard RSS James Cook. Controlled release of gas into the surface sediment and consequently into the bottom water was monitored during POS534-Leg 1. Hydroacoustic water column imaging by echosounder and ADCP was used to monitor gas bubble plume transport during the release experiment. The near- and far-field water chemistry was investigated by using towed equipment i.e. a Video-CTD water sampler rosette equipped with additional O_2-,pH-, CO_2/CH_4-sensors. Moreover, pumped water from depth was investigated by online mass spectrometry and ship-board gas sensors. Water samples were collected during the release experiment from the pumped water and by Niskin bottles of the rosette. Atmospheric CO_2 and CH_4 concentrations were measured continuously a few meters above sea surface by using a CRD spectrometer.

POS534 Leg 2 campaign concentrated on sediment (0-6 m) sampling in the vicinity of the CO_2-release spot, after the seafloor installations had been removed by RRS James Cook. Sediment cores recovered by Gravity corer and Multicorer were partly processed onboard and undisturbed sediment cores were stored for further land-based physical and biogeochemical investigations and experiments.

Moreover, as offshore wells are considered a weakening of the overburden above gas reservoirs the newly developed hydroacoustic and chemical monitoring techniques were also applied above selected abandoned well sites in the British EEZ during transit.

1.2 Zusammenfassung

Das im EU-Rahmenprogramm Horizon 2020 geförderte Projekt STEMM-CCS untersucht, wie sicher CO_2-Speicher unterhalb des Meeresbodens wären, wie ihre Dichtigkeit kontrolliert werden kann und was mögliche Gas-Lecks für die marine Umwelt bedeuten würden (https://www.stemm-ccs.eu/).

Im Rahmen diese Projekts wurde die Expedition POS534 (Leg 1 und 2) in der zentralen Nordsee durchgeführt, um das Verhalten eines am Meeresboden künstlich erzeugtes CO_2-Lecks im Gebiet der Gasförderplattform „Goldeneye“ zu untersuchen. Das Freisetzungsexperiment wurde von Bord des britischen Forschungsschiffes RRS James Cook des National Oceanography Centre Southampton (NOCS) aus installiert und kontrolliert.

Auf FS Poseidon kamen dabei diverse Messverfahren, die umfassende Analysen der Gasblasenströme und deren Lösung im Meerwasser ermöglichen zum Einsatz. Per Echolot und ADCP wurde das Lösungs- und Ausbreitungsverhalten der vom Meeresboden aufsteigenden CO_2-Gasblasen in der Wassersäule charakterisiert. Mittels eines Video-

gesteuerten Kranzwasserschöpfers wurde kontinuierlich die Konzentrationen von gelöstem CO_2 und anderer Spurengase untersucht. Hierzu kamen ein Membraneinlaß-Massenspektrometer, diverse CO_2/CH_4-Gassensoren, pH-, CTD-, O_2-Sensoren, sowie ein Durchfluß-Meßgerät für die Gesamtalkalität zum Einsatz. Wasserproben wurden parallel sowohl diskret über Niskin-Flaschen als auch kontinuierlich vom gepumpten Tiefen und Flachwasser genommen. Die Konzentrationen von CO_2 und CH_4 in der Atmosphäre wurden ebenfalls kontinuierlich über ein mobiles CRD-Spektrometer gemessen.

Darüber hinaus wurden ausgewählte verlassene Bohrlöcher, die es zu tausenden in der Nordsee gibt, daraufhin untersucht, ob ein Gasblasentransport entlang der durch die Bohrung geschaffenen Schwachstelle im Meeresboden stattfindet. Hierzu wurden ebenfalls die oben genannten hydroakustischen und chemischen Leckage-Messverfahren angewendet.

Während des zweiten Legs wurden die Oberflächensedimente (0-6 m), die nahe der künstlich erzeugten CO_2-Leckage gelegen sind, auf mögliche biogeochemische Veränderungen hin untersucht. Hierzu wurden, mittels Schwerelot und Multicorer, Sedimentkerne gewonnen und sowohl direkt an Bord beprobt, als auch für spätere Experimente an Land und weitergehende Untersuchungen am ungestörten Sediment eingelagert.

2 Participant Lists

2.1 Leg 1

Scientific Participants			Crew of RV POSEIDON	
Name	Discipline	Institution	Name	Rank
Dr. Mark Schmidt	Principle investigator, Biogeochemistry	GEOMAR	Matthias Günther	Master
Dr. Peter Linke	Co-PI, Biogeochemistry	GEOMAR	Dirk Thürsam	1st Officer
Dr. Mario Esposito	Water chemistry	GEOMAR	Ionut-Georgel Argetoianu "Janis"	2nd Officer
Maria Martinez Cabanas	Water chemistry technician	GEOMAR	Michael Rusik	Lead Engineer
Jackie Triest	KM CONTROS	KM CONTROS	Carsten Pieper	2nd Engineer
Sergiy Cherednichenko	Video/MIMS technician	GEOMAR	Hermann Pregler	Electrician
Sverre Berg	Hydroacoustics	KM SIMRAD	Ralf Meiling	Engine
Per Inge Hermundsplass	Hydroacoustics	KM SIMRAD	Dirk Heßelmann	Ship Mechanic
Andrea Bodenbinder	MIMS/water chemistry technician	GEOMAR	Frank Schrage	Bosun
Saskia Elsen	Water chemistry/public relations student	GEOMAR	Julian Langhans	Ship Mechanic
			Ronald Kuhn	Ship Mechanic
			Bernd Rau	Ship Mechanic
			Stefan Riederer	Ship Mechanic
			Ralf-Dieter Müller-Homburg	Cook
			Bernd Gerischewski	Steward

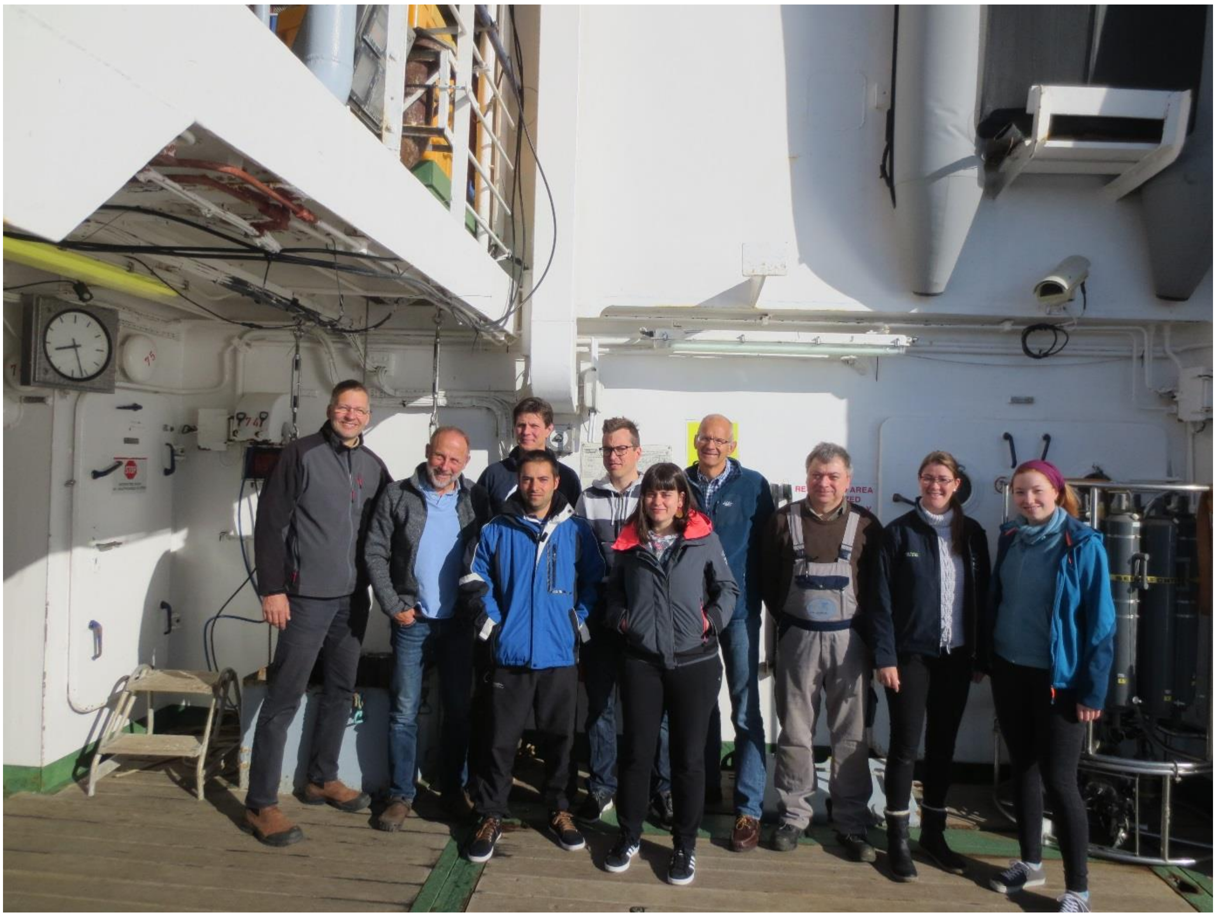
Participating institutions:

GEOMAR Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3

24148 Kiel, Germany

Kongsberg Maritime CONTROS GmbH, Wischhofstr. 1-3, 24148 Kiel, Germany

Kongsberg Maritime SIMRAD, Bontelabo 2, N-5003 Bergen, Norway



Scientific participants of Leg 1.

2.2 Leg 2

Scientific Participants			Crew of RV POSEIDON	
Name	Discipline	Institution	Name	Rank
Dr. Mark Schmidt	Principle investigator, Biogeochemistry	GEOMAR	Matthias Günther	Master
Dr. Peter Linke	Co-PI, Biogeochemistry	GEOMAR	Dirk Thürsam	1st Officer
Dr. Mario Esposito	Water chemistry	GEOMAR	Ionut-Georgel Argetoianu "Janis"	2nd Officer
Maria Martinez Cabanas	Water chemistry technician	GEOMAR	Michael Rusik	Lead Engineer
Jackie Triest	KM CONTROS	KM CONTROS	Carsten Pieper	2nd Engineer
Sergiy Cherednichenko	Video/MIMS technician	GEOMAR	Hermann Pregler	Electrician
Dr. Elke Kossel	Sediment biogeochemistry	GEOMAR	Ralf Meiling	Engine
Dr. Christian Deusner	Sediment biogeochemistry	GEOMAR	Dirk Heßelmann	Ship Mechanic

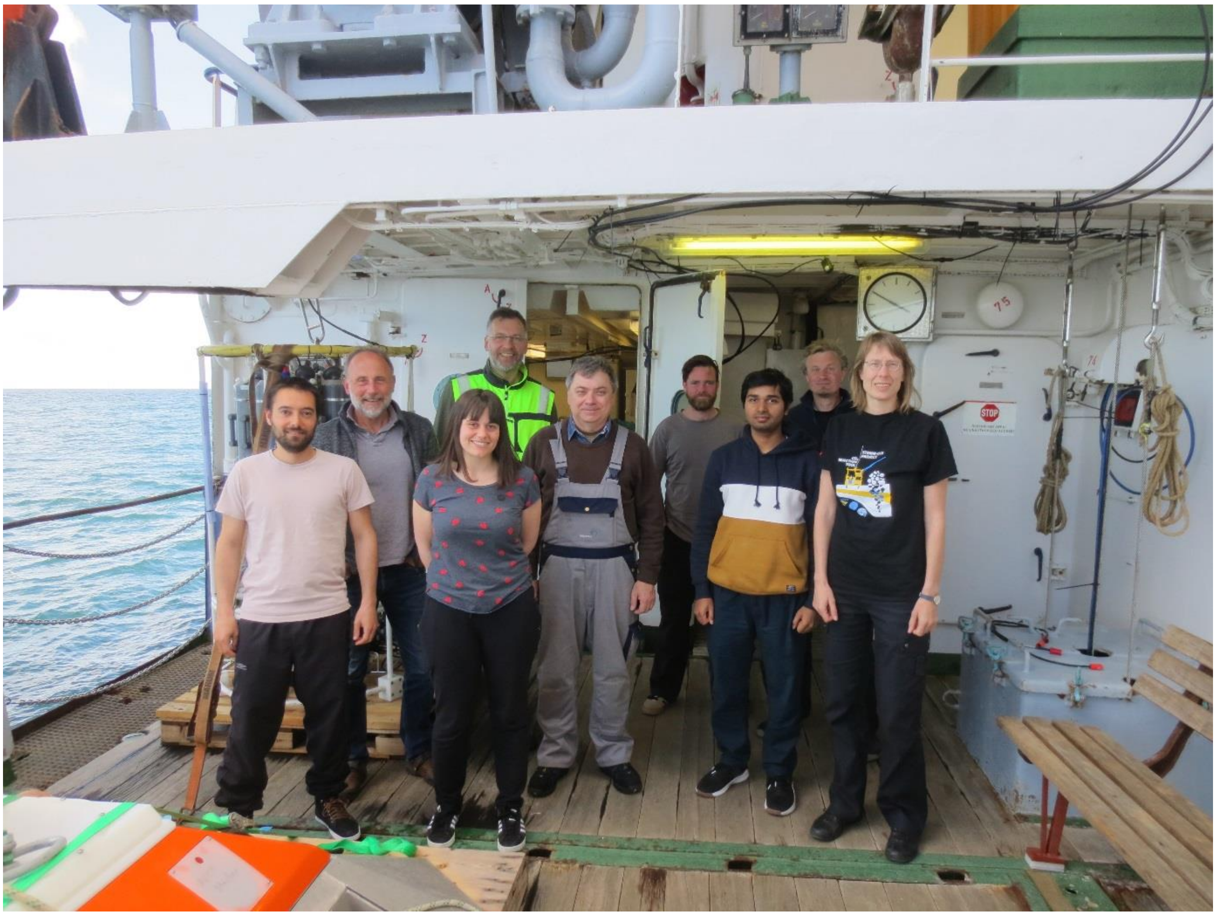
Subhadeep Rakshit (MSc)	Sediment biogeochemistry	Dalhousie Univ.	Frank Schrage	Bosun
Florian Evers	Coring technician	GEOMAR	Julian Langhans	Ship Mechanic
			Ronald Kuhn	Ship Mechanic
			Bernd Rau	Ship Mechanic
			Stefan Riederer	Ship Mechanic
			Ralf-Dieter Müller-Homburg	Cook
			Bernd Gerischewski	Steward

Participating institutions:

GEOMAR Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3

24148 Kiel, Germany

Dalhousie University, Dept. of Oceanography, Halifax, Nova Scotia, Canada B3H 4R2



Scientific participants of Leg 2.

3 Research Program / Objectives

3.1 Aims

The POS534 research cruise relates to the EU project: “Strategies for Environmental Monitoring of Marine Carbon Capture and Storage” STEMM-CCS. The cruise should provide contributions to the main aims of STEMM-CCS (i.e. WP 4, http://www.stemm-ccs.eu/work-packages):

(1) Develop and test new sensitive and robust subsea monitoring technology, which is indicative for subsea CO_2 leakage; new technology like optodes, membrane inlet mass spectrometry, active acoustics for identification and quantification of gas leakage.
(2) Tests are conducted under a controlled CO_2-release experiment at Goldeneye in the Scottish North Sea (https://www.youtube.com/watch?v=FteAvILEvzk).
(3) Porewater geochemistry, benthic flux measurement, pelagic water column monitoring provide data for quantitative interpretation of CO_2-induced biogeochemical changes by numerical modelling to improve best practice guides for CCS integrity monitoring.
(4) Hydroacoustic water column imaging and atmospheric CH_4 and CO_2-measurements above abandoned wells in the North Sea provides statistical sound carbon flux estimates from “leaky wells” into the North Sea and atmosphere.
The investigations at Goldeneye are conducted by two research vessels in parallel, the German RV Poseidon and the British RRS James Cook, to join forces on site during the CO_2 release experiment.

3.2 Work area

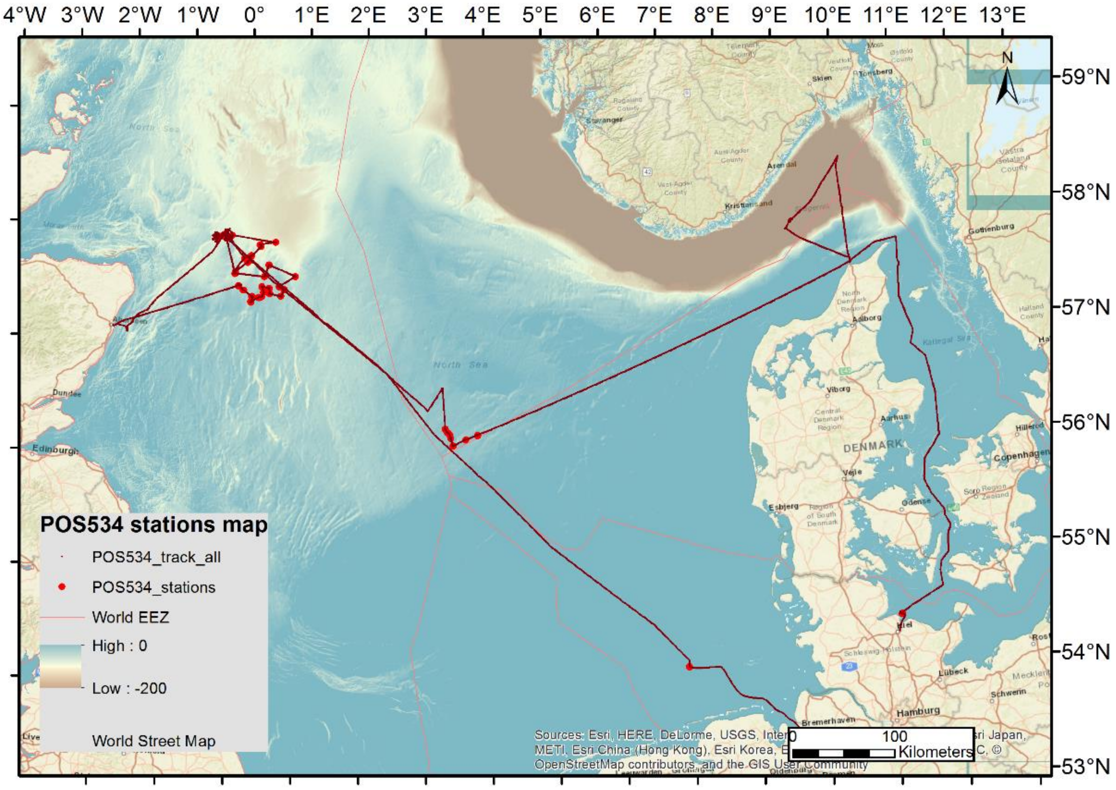


Fig. 3.2: *Map of POS534 (Leg 1 and 2) cruise track and stations (red dots).*

4 Cruise Narrative

4.1 Leg 1

Mobilization of POS534 cruise started with two days of establishing analytical devices and monitoring technology in the laboratories of the research vessel on the 29th-30th of April at Ostufer harbor, Kiel. 1st of May we started our cruise with first calibration procedures in the "Stoller Grundrinne" by using a new Kongsberg ADCP/Echosounder device installed in the moon pool. After having made a few mechanical adaptions the hydroacoustic monitoring quality was excellent and we started our transit to Hirtshals (DK), where two engineers of Kongsberg (Simrad) left us on the 3rd of May. During transit to Hirtshals most of the scientific crew members got an intensive drill on the new software and hydroacoustic hardware handling for the ADCP and echosounder systems.

Due to heavy weather conditions in the Central North Sea we were forced to stay in Skagerrak, south of Kristiansand until Monday, the 6th of May. Time was used e.g. to work on a broken fiber cable connection of the deep-sea winch on the aft deck. On the evening of the 7th of May we were able to arrive at the first working area located in the SW of the Norwegian EEZ. There, gas bubble leakage from abandoned wells was investigated by hydroacoustic water column imaging and by using the multi-purpose pumped Video-CTD. After finishing our leakage monitoring program in the Norwegian work area we arrived at Goldeneye in the evening of 9th and the first operation of priority next morning was to deploy our "SHIELD" lander, which was equipped with an upward looking current profiler (ADCP), CTD, and pH and CO_2 sensors. The device stayed at the seafloor and collected valuable data nearby the CO_2-release site until recovery on the 25th of May.

Days 10th – 13th were mainly used to conduct far-field measurements of the water column and bottom waters with the towed Video-CTD. A night-shift on the 13th to 14th gave us the first chance to monitor the CO_2-release site itself. Our partners on RRS James Cook managed to drill a pipe into the sediment and connect it to a CO_2/tracer-tank sitting at the seafloor. For the next 10 days, there had beem a controlled release of CO_2 from the seafloor into bottom water, with stepwise increasing of the gas flux. During our towed Video-CTD track we monitored gases dissolved in seawater and other parameters in the water column above the release, during a full tidal cycle. RV Poseidon did a great job in holding us exactly above the small bubble streams, although it is not equipped with Dynamic Positioning (DP).

14th to 15th, busy with hydroacoustic monitoring of the water column above abandoned wells in the British EEZ. The moon-pool installation onboard RV Poseidon, a combination of Kongsberg SIMRAD ADCP and echosounder worked perfectly and gave us excellent images of gas bubble "flares" emanating from the seafloor i.e. from abandoned wells.

Between 16th and 20th of May we were active in investigating the water column at the CO2-release site at Goldeneye again. The video-CTD with the attached water pump enabled us continuous monitoring of dissolved gas concentrations by using the onboard membrane inlet mass spectrometry and CO2 sensors. Additional in situ pH and CO2-sensor data and discrete water samples from the Niskin bottles were collected for nutrient analyses and calibration data. The video-recording always presented the seafloor "on stage" and we could follow the onset of gas bubble streams and increase of in situ sensor data in parallel.

Transit to Aberdeen started on the 20th of May. During transit we did monitor the hydroacoustic footprint of numerous decommissioned oil and gas wells in the British North Sea, finally reaching Aberdeen port on the 22nd of May, 10 am.

4.2 Leg 2

Aberdeen port was quite busy on the 22nd as a major storm event was forecast and numerous offshore supply vessels had to hide in port. Same for us. After changing part of our scientific crew in the afternoon of the 22nd we had to stay in port on the 23rd and near the coast of Scotland until the 24th.

We arrived in the Goldeneye working area again on the 25th with wind and waves calming down. Being on site we took the first chance to recover our SHIELD lander. Recovery operation went smooth and the full range of expected data records could be retrieved.

As weather was still improving during the 25th-26th of May we could conduct all of the planned gravity coring and Multi-corer stations at the CO_2-release site. Of course ROV ISIS and RRS James Cook had recovered all equipment from seafloor before (i.e. CO_2-tank, drill pipes, benthic lander, optodes, acoustic walls, etc.). It was quite a challenge when using heavy gears to hit a spot of 7 m radius at the seafloor, which is the area where CO_2 seeped out during the release experiment. Unfortunately, we had to leave the Goldeneye site in the afternoon of the 26th, before AUV surveys operated by RRS James Cook could verify our coring attempts.

Weather was stable in the night of the 28th, so we conducted a last Video-CTD and hydroacoustic station at “Figge Maar” in the German EEZ before entering the international port of Bremerhaven at 10 am on 29th of May. All equipment was unloaded to the pier expecting the transport to Kiel at the same day by truck. Unfortunately, due to customs handling, a holiday on Thursday the 30th of May, and the following weekend caused a delay of 5 days until the equipment reached our institute in Kiel.

5 Preliminary results and methods

5.1 Hydroacoustic Systems (ADCP/Single beam Echosounder)

S. Berg, P.I. Hermundsplass, S. Cherednichenko, J. Triest, M. Schmidt, P. Linke

Two hydroacoustic systems designed for current velocity/direction and water column imaging were mounted to a new adapter plate in the moon pool of RV Poseidon finally looking downwards at about 4 m water depth (Fig. 5.1-1). The EC150-3C combines a 150 kHz narrow split-beam echosounder (beamwidth of 2.5°) and a 150 kHz Acoustic Doppler Current Profiler (4-beam ADCP). The device is externally powered with 0.65A@230VAC. The ES70-18CD split-beam transducer operates at 70 kHz with 18° beamwidth, 216 dB maximum source level. It is powered and controlled by EK80 Wideband Transceiver (WBT). Both control/power units are connected via Ethernet switch to a Windows 10 laptop with EK80 software (1.13.0) installed in the dry laboratory of RV Poseidon. Calibration and tuning of the hydroacoustic design was conducted on May 1st (Station 1, Tab. 6.1). Ship’s motion and GPS data is provided by F180 motion sensor and Furuno GPS.

ADCP and echosounder data was recorded between 6th and 29th of May within British, Norwegian and German Exclusive Economic Zones (EEZ). Fig. 5.1-2 demonstrates the lowering of the pumped Video-CTD above the CO_2-release site at Goldeneye. The staircase-like strong hydroacoustic reflection in the water column (red color) of the VCTD is due to the fixing steps of the hose to the winch cable every 5 m. Gas bubble flares (CO_2, air, Kr) emanating from the seafloor are indicated by the pale green/yellow lines. An example for a strong gas bubble plume emanating from an abandoned well (i.e. 21/06-2) is shown in Fig. 5.1-3. The hydroacoustic bubble image was rising about 30 m into the water column and was only slightly bent during slack tide.

Fig. 5.1-1: *EC150-3C ADCP & echosounder and ES70-18CD echosounder mounted to a stainless steel plate to be lowered into the moon pool of RV Poseidon.*

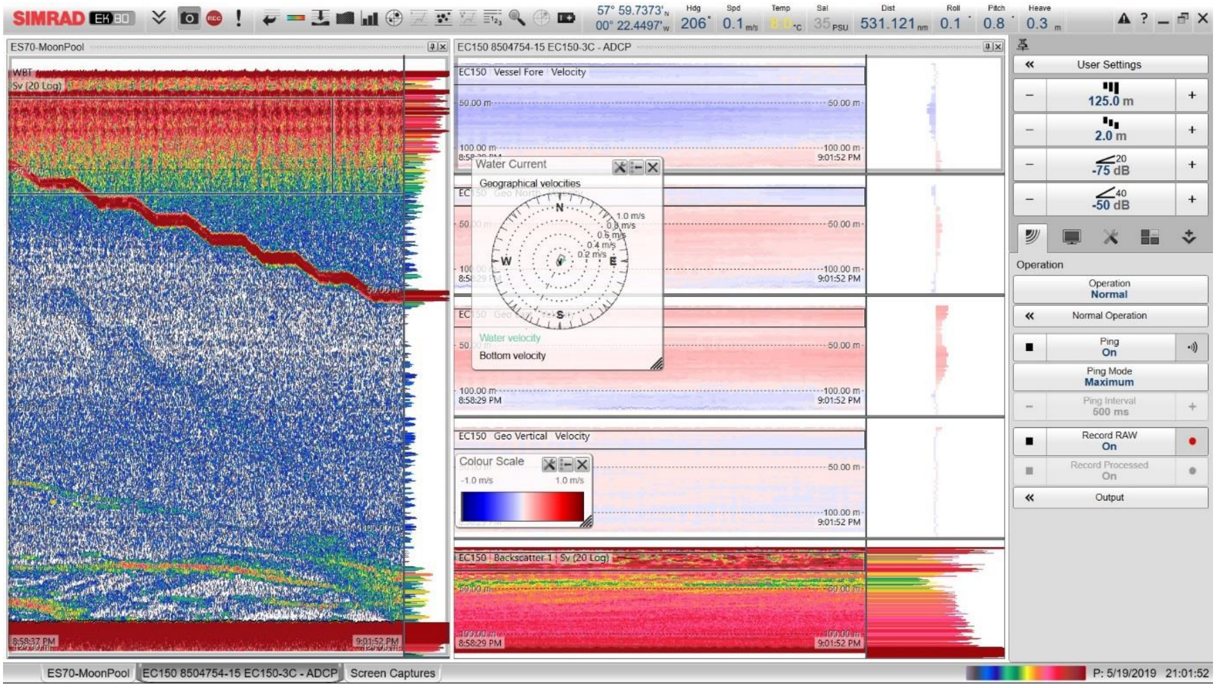


Fig. 5.1-2: *Hydroacoustic imaging of the VCTD when lowered above the CO_2-release site at Goldeneye. The emanating gas bubble streams at the seafloor and the down-going instrument, in 5 m depth intervals, can be identified (left). Simultaneously measured current vs. depth data is also shown (right). Data is recorded and visualized by EK80 software.*

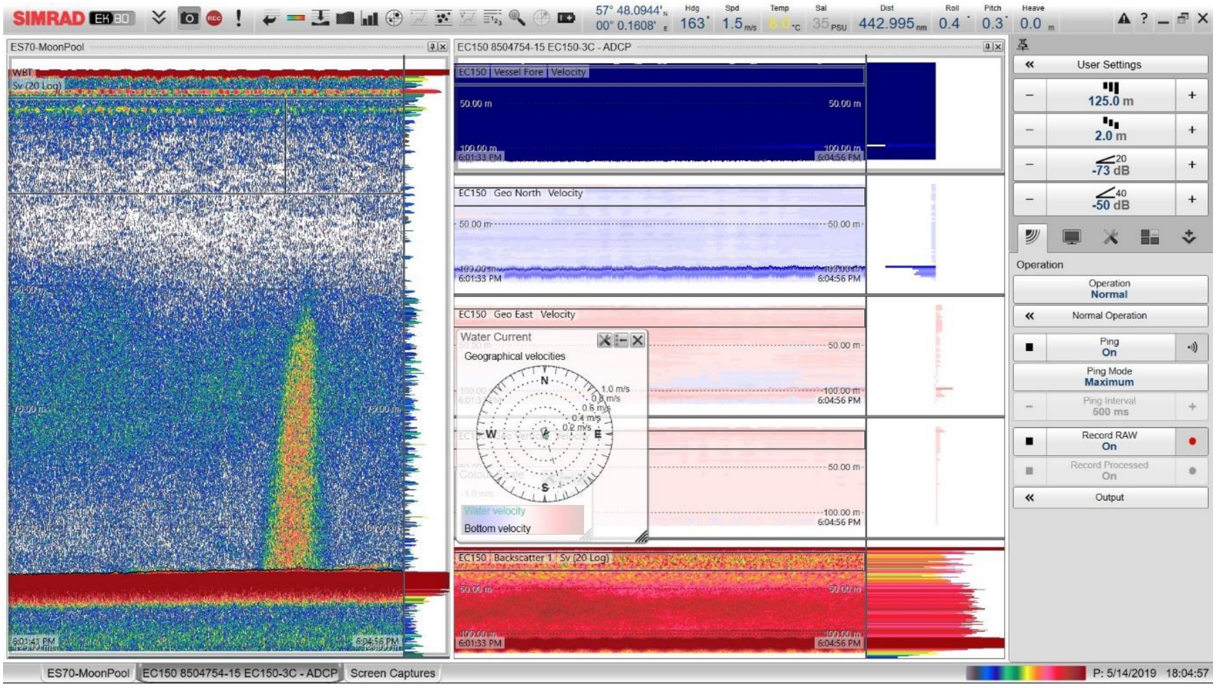


Fig. 5.1-3: *Water column image (left ES70-18 window) of a gas flare emanating from an abandoned well in the British EEZ (Well 21/6-2). The gas plume is only slightly bend in the water column due to low current (ADCP window at the right).*

5.2 Picarro atmospheric gas measurement

M. Schmidt

The atmospheric CO_2 and CH_4 concentrations were monitored during the cruise using a cavity ring down spectrometer (Picarro G2301-f CRDS) and GEOMARs 'Atmospheric Intake System' (AIS). The sampling and measuring device was installed in the wet laboratory (main deck) of RV Poseidon and was connected to three air inlets at bow, top deck and mast, respectively (Tab. 5.2-1). The air was pumped via aluminium tubing towards the Picarro analyzer. The long tubing between the AIS in the wet lab and the different air intakes caused time offsets between the air sampling and the actual gas measurement at the Picarro. Therefore each flow rate was adjusted according to the delay caused by the tubing. These delays where measured, by timing the arrival of a CO_2 peak generated by the breath of a second person at each air-intake.

The Picarro measured the different air intakes sequentially one after each other. However, after the initial delay measurement, the flow rates were tuned to adjust the delay of the different air intakes to make sure that the sequentially measured gas samples of the different air intakes originate from the same time point. Each intake was measured for one minute.

Tab. 5.2-1: *Positions of 3 different air intake nozzles mounted onboard RV Poseidon.*

Air intake ID	**Inlet location on RV Poseidon**	**Elevation above sea level (m)**	**Time of delay (s) at controlled flux (l min^{-1})**	**Calculated flow rate (l min^{-1})**
2	Bow	7.5	95 @ 1.94	2.40
3	Top deck	10	69 @ 2.166	1.51
4	Mast	13	80 @ 2.42	1.06

The atmospheric CH_4, CO_2, and water vapour concentrations were determined in real time at 2-3 Hz sampling rate changing air flow between the three intakes and the measuring unit every one minute. All data was logged on the Picarro PC in 1 hour-separated files between May 1st and 29th for post-processing. Additional parameters needed for calculating lateral distribution of sea-air gas flux, i.e. latitude, longitude, date, time, wind speed, water temperature etc. were logged by the DSHIP data system of RV Poseidon. All recorded data is available now at http://dship.geomar.de/. Data merging of ship and Picarro data and subsequent statistical calculations will be conducted by the software package GEOMAR DATA WORKBENCH (software designed by T. Weiß).

Figure 5.2-1: *Atmosphere intake system (AIS) on top of black Picarro analyzer box placed in the wet lab of RV Poseidon.*

E.g. preliminary data, i.e. atmospheric methane concentrations are plotted on a bathymetric map (Fig. 5.2-2). The data was recorded during transit from Goldeneye to Bremerhaven (27-29th of May 2019). Methane concentrations vary between 1.91 and 1.94 ppm and lateral methane distribution indicates an increase of CH_4 in more shallow coastal water and in areas of the central North Sea. The latter is possibly related to methane seepage from pockmarks (e.g. Böttner et al., 2019) or from abandoned wells (scattered green dots in Fig. 5.2-2; e.g. Vielstädte et al., 2017).

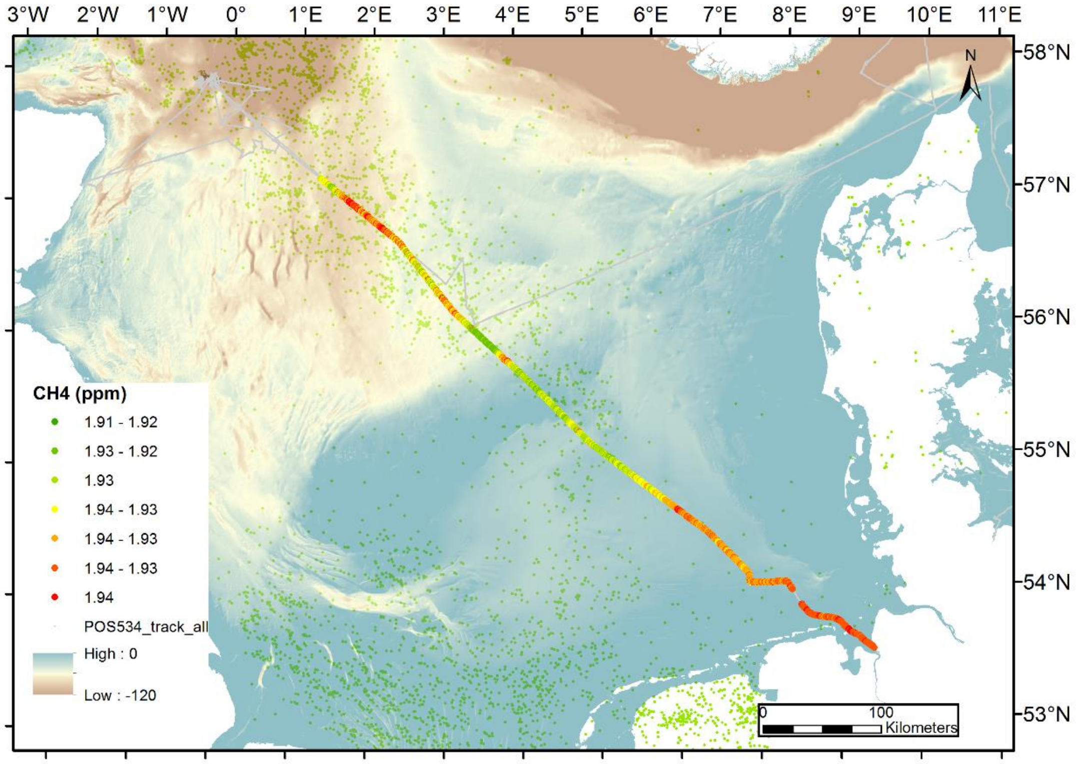


Fig. 5.2-2: *Atmospheric methane concentrations measured during 27-29 of May (intake 2 at bow; 7.5 m above sea surface).*

5.3 Underway HydroFIA-TA and Thermosalinograph

A. Bodenbinder, M. Schmidt

5.3.1 Underway Thermosalinograph

Underway temperature and conductivity data were recorded during cruise POS534 by using the shipboard Thermosalinograph. Surface waters were pumped from a port well at about 4 m water depth (inlet temperature is measured by SBE38), through a shipboard tubing system, to a flow-through tank, where temperature and conductivity is continuously measured with a SBE21 probe. Date recorded is shown on screen and can be downloaded via dship (Fig. 5.3.1-1).

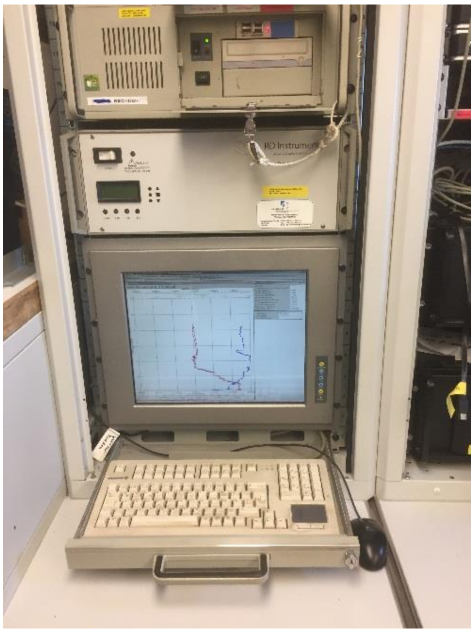


Figure 5.3.1-1: *Control unit of the Thermosalinograph.*

Conductivity (salinity) and temperature data were recorded between May 2nd/5:05 – May 22nd/06:12 and May 24th/11:31 – May 29th/07:35, respectively (Figs 5.3.1-2 and -3).

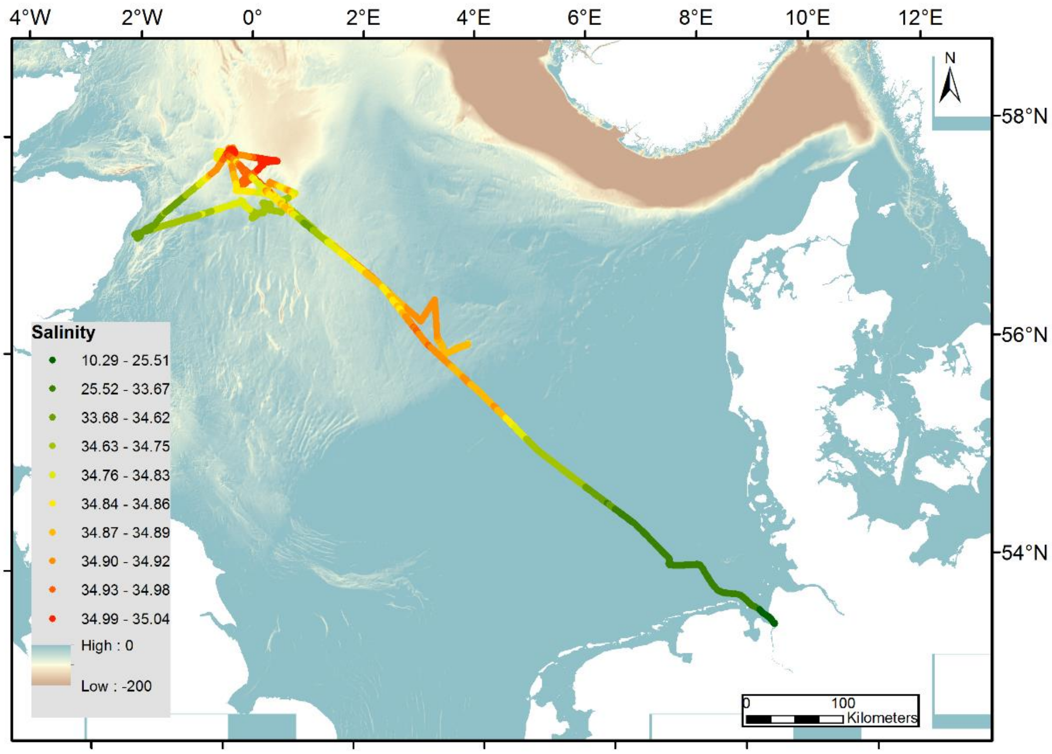


Fig. 5.3.1-2: *Salinity of surface water during POS534 cruise.*

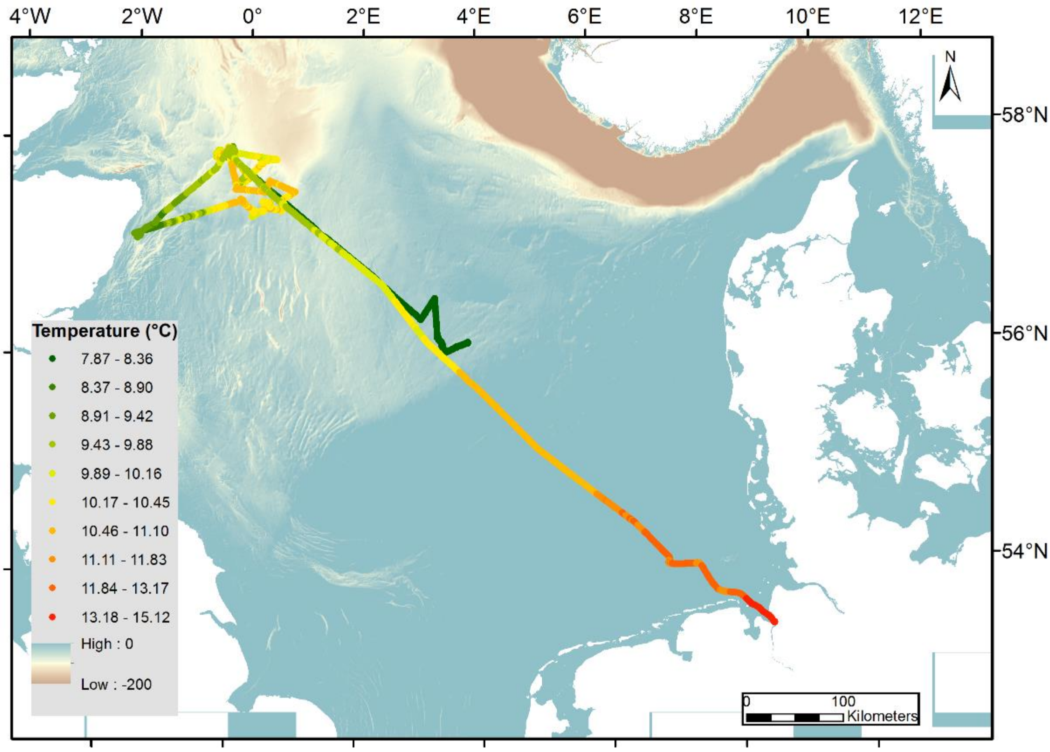


Fig. 5.3.1-3: *Surface water temperature measured during POS534 cruise.*

5.3.2 Underway Total Alkalinity (TA) measurements

A newly developed underway TA-titration system (HydroFIA™-TA, Kongsberg) applies an acidic titration on a seawater sample of defined volume and measures related pH-change by optical absorbance measurements. The TA-System was set up in the wet laboratory for measurements of seawater pumped from the port-side of RV Poseidon (2 m bsl) to the wet-lab seawater connector. Before entering the inlet of the TA-system the water is filtered by a flow-through particle filter unit (Fig. 5.3.2-1). Wastewater from TA-titrations was collected in 20 l plastic canisters for onshore disposal.

The TA-system was also used for onboard determinations of TA of discrete 100 ml water samples derived from Niskin bottle subsampling.

In total more than 1000 TA-values were determined during operations at sea between the 1st and 29th of May 2019.

Figure 5.3.2-1: *Setup of the autonomous TA-System in the wet laboratory of RV Poseidon.*

5.4 Video-CTD/Water sampler rosette

P. Linke, J. Triest, S. Cherednichenko, M. Schmidt

A video-guided Water Sampler Rosette/CTD system (VCTD, Fig. 5.4-1) was used to study the water column chemistry in the near and far field during the CO2-release experiment. The system was towed by winch 2 from the port side of RV Poseidon and water depths of the device were controlled by pressure and altimeter readings. An HD-Video camera and light sources were attached to the lower part of the frame and are controlled by the telemetry deck unit via the coaxial cable (Fig. 5.4b). The digital video and data telemetry system (Linke et al., 2015) providing real-time monitoring of the seafloor was also used to control the distance to the seafloor in “bottom view” mode. The VCTD rosette was equipped with additional sensors for pH and dissolved gases, i.e. O_2, CO_2 and CH_4, to monitor dissolved gas anomalies near the seafloor (Schmidt et al., 2015). Additionally a water pump, which connects the 120 m deep bottom water with the research vessels laboratory by a 1-inch water hose, makes it a multi-purpose oceanographic device for online water sampling and measurements in shelf areas.

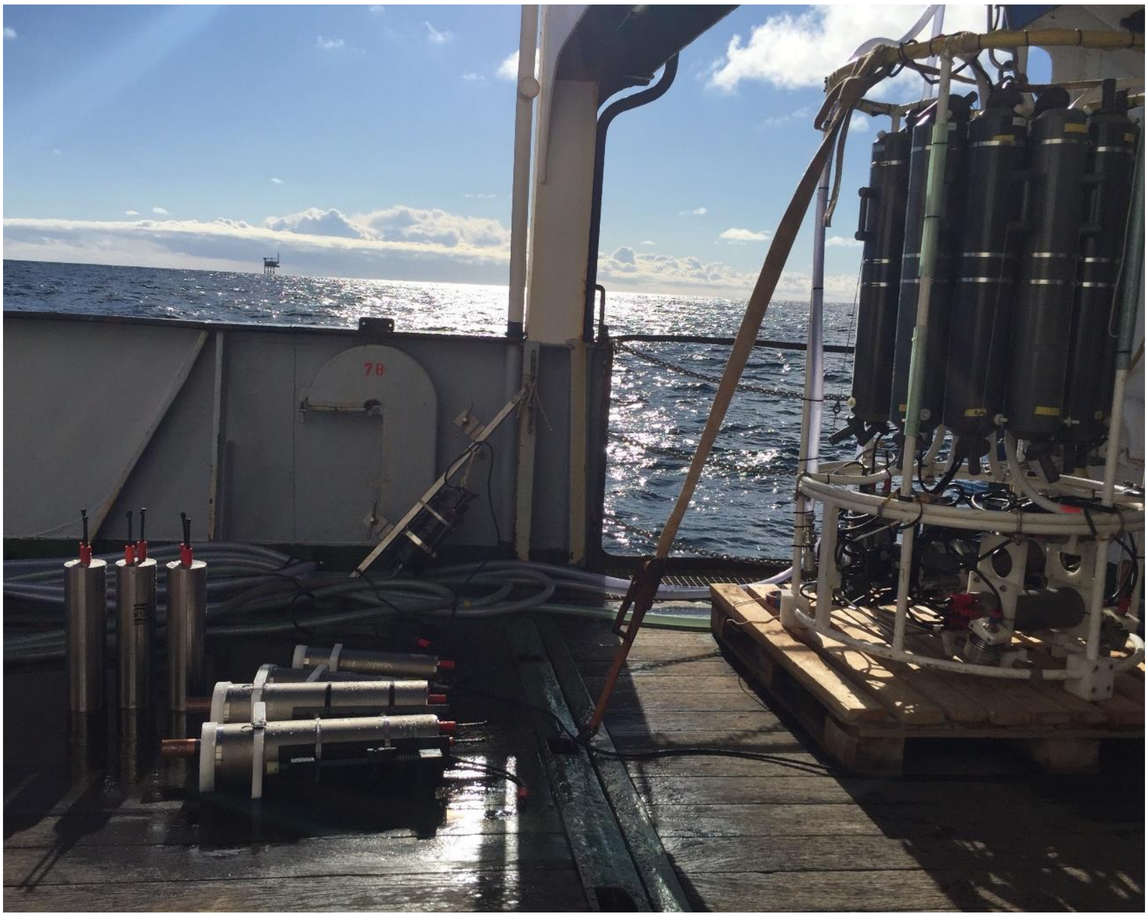


Figure 5.4-1: *Water sampler (10x10 L Niskin) rosette including SBE9plus CTD, pH/O.R.P. sensor (SBE27), O_2, and altimeter sensors. External power-packs and 2x HydroC^{TM}-CO2 and 2x HydroC^{TM}-CH4 on the left side are ready to be mounted to the rosette frame.*

SBE9plus CTD

The SBE 9plus underwater unit was equipped with pressure sensors, 2 temperature sensors, 2 oxygen sensors and 2 conductivity sensors. Furthermore, pH (SBE27) and altimeter sensors are attached. The SBE underwater unit and Niskin bottle carousel motor were powered via the winch’s coaxial-cable by using the modem/power unit from SST (Linke et al., 2015). CTD data recording and triggering Niskin bottles were controlled with SEASAVE software (version 7.21) on an external laptop. CTD data were recorded with 24 Hz. GPS position data was logged parallel to the CTD and Video data from NMEA-string of RV Poseidon (Furuno GPS).

Hydro-casts and hydrographic data from towed CTDs were processed by using SBE software SBE7.22.1. Usually data files of 1 minute bins and 1 meter bins were created from raw data files and exported to ASCII. CTD is combined with data sets from external sensors by correlating with their UTC time stamps.

SBE27-pH/O.R.P. sensor

The pH-sensor (SBE27-0287) combines a pressure balanced glass-electrode, Ag/AgCl reference probe, and a platinum O.R.P. electrode (1200 m rated).

HydroC^{TM}-CO2 sensors

The HydroC-CO2 (CO2-0412-005, CO2T-0718-001, CO2-0119-001, KM Contros) sensors, equipped with pumped (Seabird SBE-5T) sensor heads, were integrated into the Video-CTD device (Schmidt et al., 2015). Measured pCO2-data is stored internally on SD card, however, the sensors reading is also monitored onboard by using one analogue 0-5 V channel of the SBE9plus. When running in VCTD-mode the HydroC^{TM}-CO2 is powered by an external NiMH-power unit (>10h at ~16°C).

HydroC^{TM}-CH4 sensors

Up to two membrane inlet methane sensors (CH4P-0515-001, CH4P-1214-005, KM Contros) had been mounted to the steel frame replacing one Niskin bottle each. The highly sensitive methane sensors were able to detect even smallest increases of dissolved CH_4 above an average background level of 1-2 nM (Schmidt et al., 2013).

Video-CTD measurements were performed during the release experiment at different CO_2-release rates. Far field data was recorded during VCTD stations 3-6 and 9-11 (Fig. 5.4-2; Tab. 5.4-1). Near field measurements and video-observations were performed during VCTD 7, 8, and 12 (Fig. 5.4-3; Tab. 5.4-1). VCTD12 data recorded during highest (50 l/min) flow of CO_2 into the sediment at the release site is presented as an example (Fig. 5.4-4). First indications of CO2 release is measured by pH-decrease and CO_2-increase at about 4-5 m above seafloor when lowering the VCTD at the release site (Fig. 5.4-4).

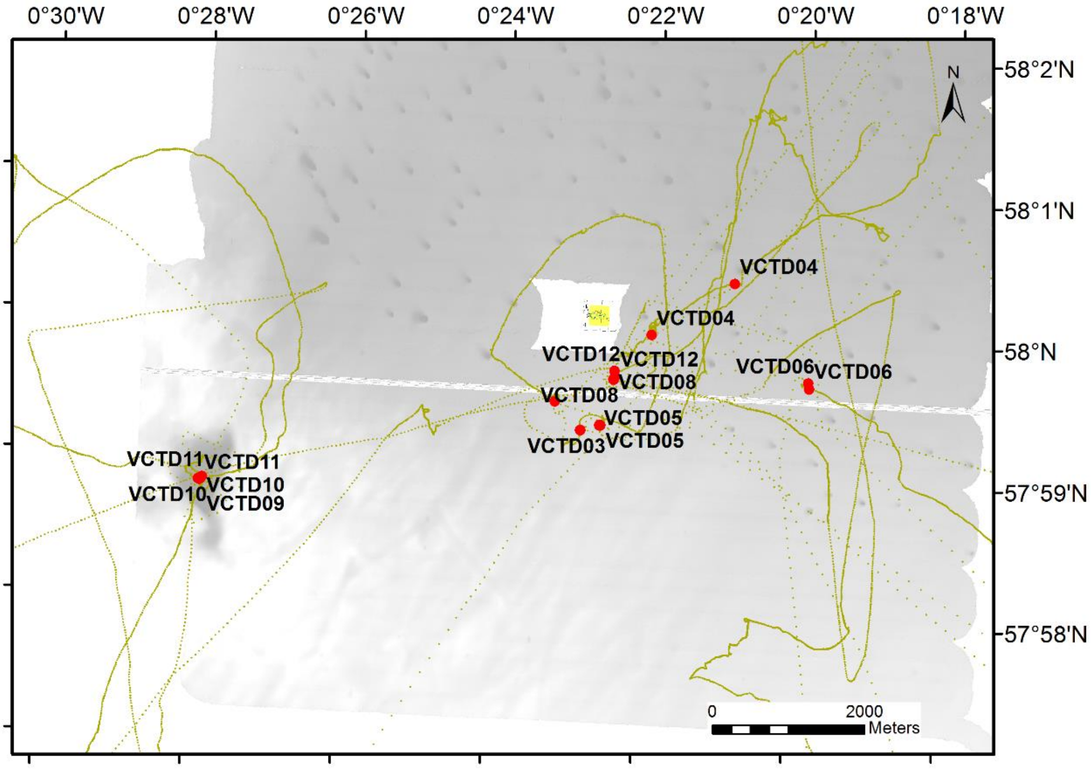


Fig. 5.4-2: *Far-field measurements conducted with towed Video-CTD. Dotted green line marks the RV Poseidon track. Red dots mark start and end-position of VCTD stations.*

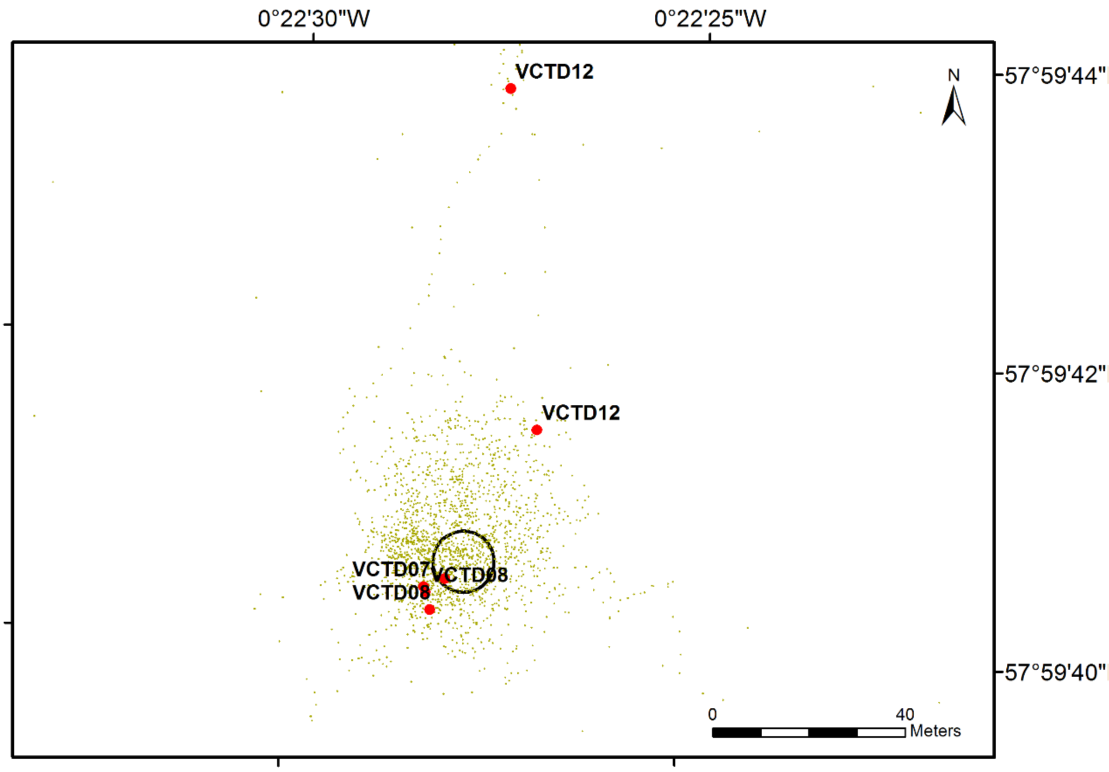


Fig. 5.4-3: *Towed Video-CTD measurements at the Goldeneye release site. The 7 m circle around the CO_2-release spot is shown on the map. Start and end of VCTD stations are marked in red. Green dots indicate measurements per 1 minute interval.*

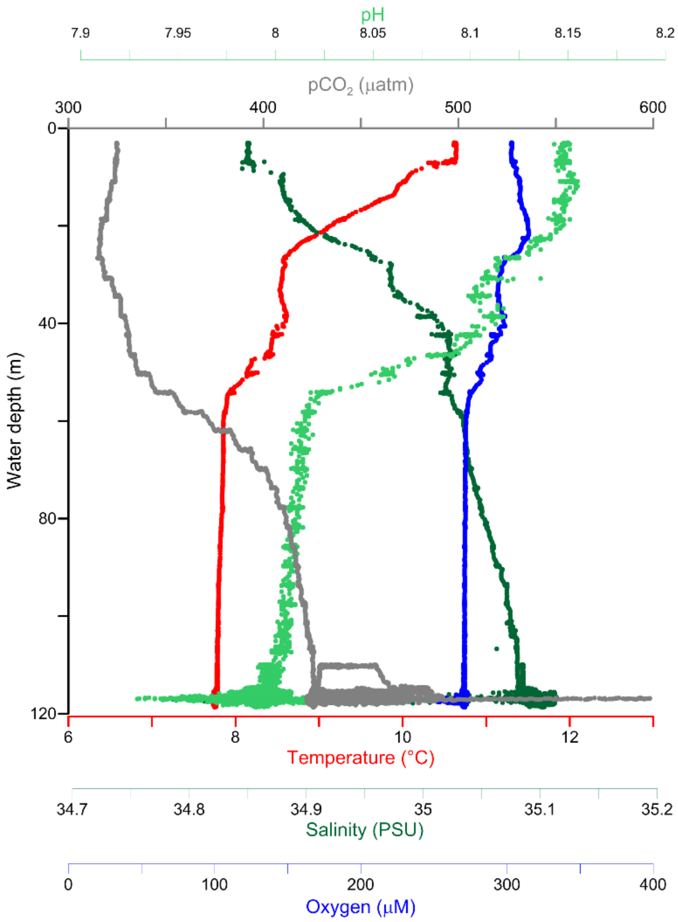


Fig. 5.4-4: *VCTD12 data recorded between 19.05.2019 20:56:11 and 20.05.2019 03:42:14 at the release site (CO2-release rate: 50 l/min).*

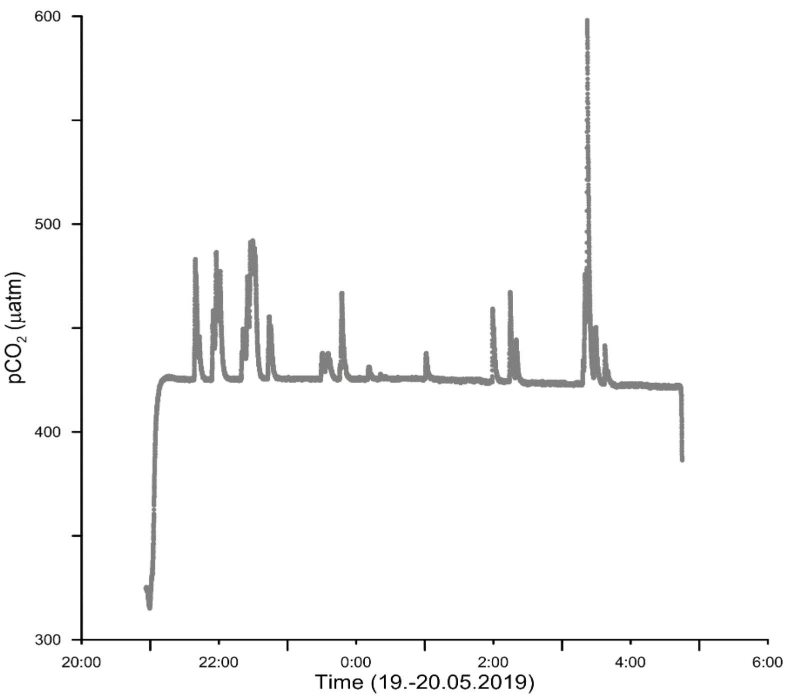


Fig. 5.4-5: *pCO_2 data of Contros HydroC-CO2 sensor recorded during VCTD12 down/up-cast and transects above the CO_2-release site at about 2-3 m above seafloor.*

Tab. 5.4-1: *Video-CTD stations performed during POS534 cruise.*

Station ID	Date time	Area	VCTD No.	Action	Latitude	Longitude	Water Depth (m)
POS534 1	01.05.2019 08:58	Stoller Grund Rinne	VCTD 01	in the water	54° 29.409' N	010° 13.940' E	10.9
POS534 1	01.05.2019 09:38	Stoller Grund Rinne	VCTD 01	on deck	54° 29.401' N	010° 14.053' E	11
POS534 10	08.05.2019 07:35	N 2/7-11	VCTD 02	in the water	56° 19.776' N	003° 18.433' E	67
POS534 10	08.05.2019 11:54	N 2/7-11	VCTD 02	on deck	56° 19.769' N	003° 18.415' E	67
POS534 12	10.05.2019 08:00	Goldeneye	VCTD 03	in the water	57° 59.493' N	000° 23.233' W	118
POS534 12	10.05.2019 14:59	Goldeneye	VCTD 03	on deck	57° 59.299' N	000° 22.877' W	116.7
POS534 14	11.05.2019 06:13	Goldeneye	VCTD 04	in the water	57° 59.996' N	000° 21.987' W	118
POS534 14	11.05.2019 15:03	Goldeneye	VCTD 04	on deck	58° 00.388' N	000° 20.913' W	119.2
POS534 15	12.05.2019 06:18	Goldeneye	VCTD 05	in the water	57° 59.343' N	000° 22.608' W	117
POS534_15-1	12.05.2019 14:41	Goldeneye	VCTD 05	on deck	57° 59.340' N	000° 22.628' W	115.2
POS534_16-1	13.05.2019 06:04	Goldeneye	VCTD 06	in the water	57° 59.709' N	000° 19.865' W	118.2
POS534_16-1	13.05.2019 09:28	Goldeneye	VCTD 06	on deck	57° 59.670' N	000° 19.852' W	117.2
POS534_17-1	13.05.2019 16:44	Goldeneye	VCTD 07	in the water	57° 59.674' N	000° 22.462' W	117.2
POS534_17-1	14.05.2019 02:58	Goldeneye	VCTD 07	on deck	57° 59.673' N	000° 22.467' W	118
POS534_30-1	16.05.2019 18:03	Goldeneye	VCTD 08	in the water	57° 59.670' N	000° 22.465' W	118.5
POS534_30-1	17.05.2019 03:43	Goldeneye	VCTD 08	on deck	57° 59.672' N	000° 22.466' W	118.5
POS534_32-1	18.05.2019 07:03	Goldeneye SW	VCTD 09	in the water	57° 58.823' N	000° 27.916' W	118.5
POS534_32-1	18.05.2019 08:54	Goldeneye SW	VCTD 09	on deck	57° 58.823' N	000° 27.900' W	118.5
POS534_33-1	18.05.2019 12:01	Goldeneye SW	VCTD 10	in the water	57° 58.821' N	000° 27.935' W	118.5
POS534_33-1	18.05.2019 14:50	Goldeneye SW	VCTD 10	on deck	57° 58.837' N	000° 27.887' W	118.5
POS534_34-1	19.05.2019 06:31	Goldeneye SW	VCTD 11	in the water	57° 58.836' N	000° 27.898' W	118.5
POS534_34-1	19.05.2019 08:53	Goldeneye SW	VCTD 11	on deck	57° 58.816' N	000° 27.918' W	118.5
POS534_35-1	19.05.2019 20:47	Goldeneye	VCTD 12	in the water	57° 59.729' N	000° 22.454' W	118.5
POS534_35-1	20.05.2019 04:46	Goldeneye	VCTD 12	on deck	57° 59.691' N	000° 22.445' W	118.5
POS534_68-1	28.05.2019 11:06	Figge Maar	VCTD 13	in the water	54° 10.063' N	006° 58.024' E	31.2
POS534_68-1	28.05.2019 13:00	Figge Maar	VCTD 13	on deck	54° 10.081' N	006° 58.107' E	32.2

5.5 Video-sled

S. Cherednichenko, P. Linke, J. Triest, M. Schmidt

The detection of leakages from abandoned wells was one scientific objective of cruise POS534. Therefore, a video sled was used carrying a novel underwater mass spectrometer in combination with an autonomous acoustic WBAT/EK80 system provided by KM Simrad (Fig. 5.5-1). The distribution of gases (CH_4, pCO_2, N_2, Ar) were continuously and simultaneously recorded using the UW-MIMS (Sommer et al., 2019), which was deployed in combination with two separate sensors for the measurement of pCO_2 and CH_4 (HydroC CO_2, HydroC CH_4, both from Kongsberg Maritime Contros), temperature-, pressure-, and pH-sensor as well as a video camera system for seafloor imaging. A glass fiber telemetry developed at GEOMAR allowed online transfer of video and sensor data as well as for the complete online operational control of the mass spectrometer via the fiber optic cable on the mobile winch of GEOMAR (Fig. 5.5-2). The system was deployed using the A-frame at the stern of the vessel and towed in about 1 to 1.5 m distance above the seafloor. The towing speed was maximum 0.5 kt.

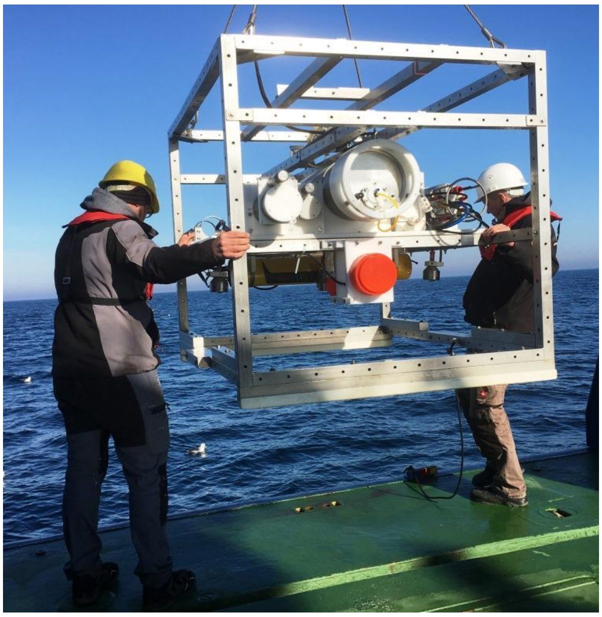


Fig. 5.5-1: *Deployment of the video sled equipped with CH_4 and CO_2 sensors, MIMS, telemetry (from left to right in the top section of the frame) and LED lights, video camera, WBAT/EK80 system connected to a forward- and a downward-facing orange transducer, respectively (lower section).*

Fig. 5.5-2: *Remotely controlled winch operation.*

Fig. 5.5-3: *Remote operational control of winch and mass spectrometer in the onboard laboratory*

Recorded in situ hydroacoustic and chemical data were stored on internal hard drives and flash memories. Additionally, online access to data and remote control of e.g. mass spectrometer, video camera, and gas sensors from onboard laboratory was enabled (Fig. 5.5-3).

Parallel to in situ measurements the ship GPS position as well as the hydro-acoustic water column images recorded with the ADCP/ES device mounted in the moon pool of RV Poseidon was logged and will be combined with gas measurements.

In total three towed stations were conducted on the 15th and 16th of May above abandoned well areas (Stations 23, 24 and 29 in Tab. 6-1).

5.6 Water column sampling

M. Esposito, A. Bodenbinder, S. Elsen, M. Martinez Cabanas

5.6.1 Inorganic nutrients sampling

Dissolved inorganic carbon and total alkalinity sampling

The 10 x 10 L Niskin bottles rosette mounted on the frame of the video-guided CTD system was used for discrete water sampling. Additional samples were collected from the on-board outlet of the Video-pump CTD system. The water was continuously pumped from a specific water depth into the on-board Membrane Inlet Mass Spectrometer (MIMS) for real-time analysis. A three way tube connector was installed in order to split the flow and allow for water sample collection.

Samples for Total Alkalinity and Dissolved Inorganic Carbon (TA/DIC) were drawn directly from the Niskin bottles and pump system into 250 ml Pyrex borosilicate glass bottles. Bottles were rinsed at least three times with the seawater before filling. While filling, the bottles were rotated to ensure no bubbles accumulate inside and to avoid the persistence of any minute bubbles, overflowing was allowed. After removal of 2.5 ml of sampled seawater for headspace, samples were preserved by addition of 100 µl of 50% saturated $HgCl_2$ solution (Dickson et al. 2007). A thin layer of silicone grease was applied around the glass stoppers and after appropriate labelling, the bottles were sealed and stored in the dark for later analysis at GEOMAR.

Stable carbon isotopes sampling

Additionally, samples for DIC and stable carbon isotope ($\delta^{13}C_{DIC}$) analysis were collected into 12 mL Exetainer vials (LABCO). For collection of the water, a small tube was connected directly to the Niskin bottles or pump system and used to drawn the samples. The tube was inserted into the vials down to the bottom. Filling was carefully undertaken in order to avoid formation of air bubbles. Overflowing was allowed. The samples were then preserved by the addition of 10 µl of 50% saturated $HgCl_2$ solution. Vials were capped without leaving any headspace, appropriately labelled and stored cool and dark for subsequent analysis at the National Oceanography Centre in Southampton.

Dissolved organic carbon and dissolved organic nitrogen sampling
Samples for dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) were collected from CTD casts. One end of a silicone tubing was connected directly to the tap of the Niskin bottle while at the other end a stainless steel filter holder was attached. Ashed (combusted at 450 °C for 4 hours) 25 mm glass fiber (GF/F; Whatmann) filters with a nominal pore size 0.45 µm were placed in the filter holder for sampling. The filtered water was collected directly into pre-combusted 25 ml borosilicate glass vials. Vials were capped and following appropriate labelling, they were stored in the cold and dark for subsequent analysis at GEOMAR. Analysis will be performed by high temperature combustion on a Shimadzu TOC V series analyser.

Inorganic nutrients sampling
Samples for inorganic nutrients (nitrate/nitrite, phosphate and silicic acid) were collected from CTD casts and pump system. Water samples were drawn directly from the Niskin bottles and pump outlet into acid washed (10% HCl) 60 ml Nalgene bottles. During sampling, latex gloves were worn in order to avoid contamination. Bottles and lids were rinsed at least 3 times with sampling water before filling. After appropriate labelling, the bottle samples were frozen (-20 °C) for later analysis on a QuAAtro (Seal Analytical) segmented flow analyser at GEOMAR.

During Poseidon 534 cruise, a total of 10 vertical profile Video-CTD casts and 7 pump-VCTDs were used to collect water from the Goldeneye area and surroundings (Table 5.6.1-11). At each station a variable number of Niskin bottles were fired at selected water depths to collect DIC/TA, $\delta^{13}C_{DIC}$, DOC/DON and nutrient samples. Regular sampling from the on-board outlet of the pump VCTD system was also undertaken.

Table 5.6.1-1: *List of carbonate and inorganic nutrient samples collected on the POS534 cruise*

Date	Time (UTC)	Station	Latitude	Longitude	Sampling device	Depth (m)	DIC	$\delta^{13}C_{DIC}$	DOC	Nutrients
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	66	x	x	x	x
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	66	x	x	x	x
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	66	x	x	x	x
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	59	x	x	x	x
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	47	x	x	x	x
08/05/2019	12:00	VCTD02	56.3295	3.3075	VCTD	23	x	x	x	x
10/05/2019	10:20	VCTD03	58.00122	-0.3988	Pump-VCTD	118	x	x		x
10/05/2019	10:40	VCTD03	58.00543	-0.3941	Pump-VCTD	118	x	x		x
10/05/2019	11:00	VCTD03	58.00833	-0.3903	Pump-VCTD	118	x	x		x
10/05/2019	11:20	VCTD03	58.01133	-0.3848	Pump-VCTD	118	x	x		x
10/05/2019	11:40	VCTD03	58.01217	-0.3813	Pump-VCTD	117	x	x		x

10/05/2019	12:00	VCTD03	58.01383	-0.3738	Pump-VCTD	118	x	x		x
10/05/2019	12:20	VCTD03	58.01267	-0.3660	Pump-VCTD	118	x	x		x
10/05/2019	12:40	VCTD03	58.0085	-0.3645	Pump-VCTD	118	x	x		x
10/05/2019	13:00	VCTD03	58.00433	-0.3637	Pump-VCTD	117	x	x		x
10/05/2019	13:20	VCTD03	58.00017	-0.3628	Pump-VCTD	118	x	x		x
10/05/2019	13:40	VCTD03	57.99567	-0.3630	Pump-VCTD	117	x	x		x
10/05/2019	14:00	VCTD03	57.99117	-0.3660	Pump-VCTD	116	x	x		x
10/05/2019	14:20	VCTD03	57.98883	-0.3703	Pump-VCTD	117	x	x		x
10/05/2019	14:50	VCTD03	57.98983	-0.3810	VCTD	115	x	x	x	x
10/05/2019	14:50	VCTD03	57.98983	-0.3810	VCTD	68	x	x	x	x
10/05/2019	14:50	VCTD03	57.98983	-0.3810	VCTD	45	x	x	x	x
10/05/2019	14:50	VCTD03	57.98983	-0.3810	VCTD	26	x	x	x	x
10/05/2019	14:50	VCTD03	57.98983	-0.3810	VCTD	26	x	x	x	x
10/05/2019	16:00	VCTD03	57.9885	-0.3847	Pump-VCTD	118	x	x		x
10/05/2019	16:15	VCTD03	57.99517	-0.3980	Pump-VCTD	118	x	x		x
10/05/2019	16.3	VCTD03	58.00833	-0.3903	Pump-VCTD	118	x	x		x
10/05/2019	16:45	VCTD03	58.0135	-0.3770	Pump-VCTD	118	x	x		x
10/05/2019	17:00	VCTD03	58.0065	-0.3640	Pump-VCTD	118	x	x		x
10/05/2019	17:15	VCTD03	57.99367	-0.3645	Pump-VCTD	118	x	x		x
10/05/2019	17:30	VCTD03	57.99067	-0.3827	Pump-VCTD	118	x	x		x
11/05/2019	07:00	VCTD04	58.00017	-0.3663	Pump-VCTD	118	x	x		x
11/05/2019	08:00	VCTD04	58.00017	-0.3663	Pump-VCTD	118	x	x		x
11/05/2019	09:00	VCTD04	58.00017	-0.3663	Pump-VCTD	117	x	x		x
11/05/2019	10:00	VCTD04	58.00017	-0.3663	Pump-VCTD	118	x	x		x
11/05/2019	11:00	VCTD04	58.00017	-0.3663	Pump-VCTD	117	x	x		x
11/05/2019	12:00	VCTD04	58.00017	-0.3663	Pump-VCTD	117	x	x		x
11/05/2019	13:00	VCTD04	58.00017	-0.3663	Pump-VCTD	117	x	x		x
11/05/2019	13:34	VCTD04	58.00008	-0.3662	VCTD	60	x	x	x	x
11/05/2019	13:34	VCTD04	58.00008	-0.3662	VCTD	45	x	x	x	x
11/05/2019	13:34	VCTD04	58.00008	-0.3662	VCTD	30	x	x	x	x
11/05/2019	13:34	VCTD04	58.00008	-0.3662	VCTD	15	x	x	x	x
11/05/2019	13:34	VCTD04	58.00008	-0.3662	VCTD	5	x	x	x	x
12/05/2019	07:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	08:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	09:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	10:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	11:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	12:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	13:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	14:00	VCTD05	57.98917	-0.3773	Pump-VCTD	116	x	x		x
12/05/2019	14:30	VCTD05	57.9890	-0.3768	VCTD	60	x	x	x	x
12/05/2019	14:30	VCTD05	57.9890	-0.3768	VCTD	46	x	x	x	x
12/05/2019	14:30	VCTD05	57.9890	-0.3768	VCTD	31	x	x	x	x
12/05/2019	14:30	VCTD05	57.9890	-0.3768	VCTD	7	x	x	x	x
13/05/2019	07:00	VCTD06	57.99483	-0.3738	Pump-VCTD	117	x	x		x
13/05/2019	07:20	VCTD06	57.99483	-0.3738	Pump-VCTD	100	x	x		x
13/05/2019	07:40	VCTD06	57.99483	-0.3738	Pump-VCTD	80	x	x		x

13/05/2019	08:00	VCTD06	57.99483	-0.3738	Pump-VCTD	60	x	x		x
13/05/2019	08:40	VCTD06	57.99483	-0.3738	Pump-VCTD	39	x	x		x
13/05/2019	09:00	VCTD06	57.99483	-0.3738	Pump-VCTD	30	x	x		x
13/05/2019	09:15	VCTD06	57.99483	-0.3738	Pump-VCTD	15	x	x		x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	117	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	101	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	81	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	62	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	42	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	33	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	18	x	x	x	x
13/05/2019	09:15	VCTD06	57.99483	-0.3325	VCTD	7	x	x	x	x
13/05/2019	18:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
13/05/2019	19:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
13/05/2019	20:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
13/05/2019	21:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
13/05/2019	22:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
13/05/2019	23:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
14/05/2019	00:00	VCTD07	57.9945	-0.3738	Pump-VCTD	117	x	x	x	x
14/05/2019	01:00	VCTD07	57.9945	-0.3738	Pump-VCTD	108	x	x	x	x
14/05/2019	02:00	VCTD07	57.9945	-0.3738	Pump-VCTD	98	x	x	x	x
14/05/2019	02:30	VCTD07	57.99315	-0.3571	Pump-VCTD	98	x	x	x	x
14/05/2019	03:00	VCTD07	57.99315	-0.3571	VCTD	115	x	x	x	x
14/05/2019	03:00	VCTD07	57.99315	-0.3571	VCTD	108	x	x	x	x
14/05/2019	03:00	VCTD07	57.99315	-0.3571	VCTD	98	x	x	x	x
14/05/2019	03:00	VCTD07	57.99315	-0.3571	VCTD	91	x	x	x	x
16/05/2019	19:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
16/05/2019	20:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
16/05/2019	21:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
16/05/2019	22:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
16/05/2019	23:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	00:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	00:45	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	01:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	02:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	03:00	VCTD08	57.9945	-0.3747	Pump-VCTD	115	x	x		x
17/05/2019	04:00	VCTD08	57.99452	-0.3745	VCTD	115	x	x	x	x
17/05/2019	04:00	VCTD08	57.99451	-0.3746	VCTD	106	x	x	x	x
17/05/2019	04:00	VCTD08	57.99451	-0.3746	VCTD	96	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	113	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	118	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	109	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	89	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	62	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	50	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	38	x	x	x	x
18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	20	x	x	x	x

18/05/2019	07:30	VCTD09	57.9805	-0.4653	VCTD	5	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	122	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	119	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	110	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	90	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	60	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	50	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	38	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	20	x	x	x	x
19/05/2019	10:40	VCTD11	57.98046	-0.46524	VCTD	5	x	x	x	x
19/05/2019	22:00	VCTD12	57.99467	-0.3743	Pump-VCTD	116	x	x		x
19/05/2019	22:40	VCTD12	57.99467	-0.3743	Pump-VCTD	116	x	x		x
19/05/2019	23:00	VCTD12	57.99467	-0.3743	Pump-VCTD	117	x	x		x
20/05/2019	00:00	VCTD12	57.99467	-0.3743	Pump-VCTD	116	x	x		x
20/05/2019	01:00	VCTD12	57.99467	-0.3743	Pump-VCTD	118	x	x		x
20/05/2019	02:00	VCTD12	57.99467	-0.3743	Pump-VCTD	116	x	x		x
20/05/2019	03:00	VCTD12	57.99467	-0.3743	Pump-VCTD	116	x	x		x
20/05/2019	03:30	VCTD12	57.99467	-0.3747	Pump-VCTD	116	x	x		x
20/05/2019	04:15	VCTD12	57.9945	-0.3743	VCTD	116	x	x	x	x
21/05/2019	05:15	VCTD12	57.9945	-0.3743	VCTD	116	x	x	x	x
22/05/2019	06:15	VCTD12	57.9945	-0.3743	VCTD	107	x	x	x	x
23/05/2019	07:15	VCTD12	57.9945	-0.3743	VCTD	95	x	x	x	x
TOTAL							127	127	62	127

5.6.2 Dissolved gases, onboard total alkalinity and anions of water column

Niskin bottles and the tube outlet for pumped water from depth were subsampled for analysing selected parameters onboard RV Poseidon and in GEOMAR laboratories (Tab. 5.6.2-1).

100-ml glass bottles were filled with seawater samples from Niskin bottles, closed and stored for direct onboard TA-measurements with HydroFIA-TA.

100-ml glass vials were filled with water from Niskin samplers and were crimped with rubber stoppers. Then 10 ml of helium was added, replacing seawater of 10 ml, to extract dissolved gases into the headspace. Filled glass vials were poisoned with 50 µl of saturated $HgCl_2$-solution and stored after mixing for further gas chromatographic and stable isotope measurements of headspace gas at GEOMAR.

12 ml of pre-cleaned plastic vials were filled with 10 ml filtered (0.2 µm) seawater and frozen at -18C ° for further nutrient measurements with an autoanalyzer at GEOMAR.

20-ml glass vials were filled with seawater from Niskin samplers and were crimped with rubber stoppers. Filled glass vials were poisoned with 10 µl of saturated $HgCl_2$-solution and stored after mixing for further mass spectrometric gas determinations (MIMS) at GEOMAR.

Dissolved oxygen of 10 ml subsamples was determined by using onboard Winkler titration method (Grasshoff et al., 1999).

Tab. 5.6.2-1: *Subsamples taken from Niskin bottles and tube outlet for subsequent chemical analyses.*

Station	Datum	O2 (Winkler)	TA (HydroFIA)	Dissolved gas (GC)	Dissolved gas (MIMS)	Anions (IC)	Niskin bottle No.
Seawater wetlab	04.05.2019	x					
Sensor test CTD	05.05.2019			x		x	2+3
10VCTD2B_2	08.05.2019	x	x	x	x	x	1+2+3+5+6+7
12VCTD03	10.05.2019	x	x	x	x	x	1+2+3+5+6
14VCTD04	11.05.2019		x				tube
14VCTD04	11.05.2019	x	x	x	x	x	1+2+3+5+6
15VCTD05	12.05.2019		x				tube
15VCTD05	12.05.2019	x	x	x	x	x	1+2+3+6
16VCTD06	13.05.2019		x				tube
16VCTD06_B_C	13.05.2019	x	x	x	x	x	2+3+6+7 +8+9+11+12
17VCTD07	13.05.2019-14.05.2019		x				tube
17VCTD07	14.05.2019	x	x	x	x	x	1+2+3+5
30VCTD08	16.05.2019-17.05.2019		x				tube
30VCTD08	17.05.2019	x	x	x	x	x	1+2+3
32VCTD09	18.05.2019	x	x	x	x	x	1+2+3+5 +6+7+8+9+10
34VCTD11	19.05.2019	x	x	x	x	x	1+2+3+5+6+ 7+8+9+10
35VCTD12	19.05.2019-20.05.2019		x				tube
35VCTD12	20.05.2019	x	x	x	x	x	1+2+3+5

7 Lander operations

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5.7.1 Lander deployment and recovery

In order to provide environmental baseline data during the controlled CO_2 release experiment, a trawl resistant lander (TRL AL-200, Floatation technologies) was used. The lander is composed of two parts: the upper floatation unit (Fig. 5.7.1-1) and the lower anchoring base (Fig. 5.7.1-2). The floatation unit carried an ADCP (300 kHz, Teledyne RDI) and keeps it with a double axis gimbal oriented to vertical (Fig. 5.7.1-3). The base was equipped with a storage CTD (SBE 37IM, Sea-Bird), a CO_2 and a pH-sensor with internal data logger (University of Technology Graz), respectively. For recovery the base of the lander is further equipped with an acoustic release (K/MT562, KUM) which enables the floatation unit to detach from the lander base and to ascend to the sea surface (Fig. 5.7.1-4). It is connected to the base of the lander with a 300 m long Spectra line, which enables a recovery of the whole lander. Like using a parachute great care has to be taken during preparation of the deployment to ensure a safe recovery without entangling of the line (Fig. 5.7.1-2).

Fig. 5.7.1-1: *Upper floatation unit with double axis gimbal and black recovery rope.*

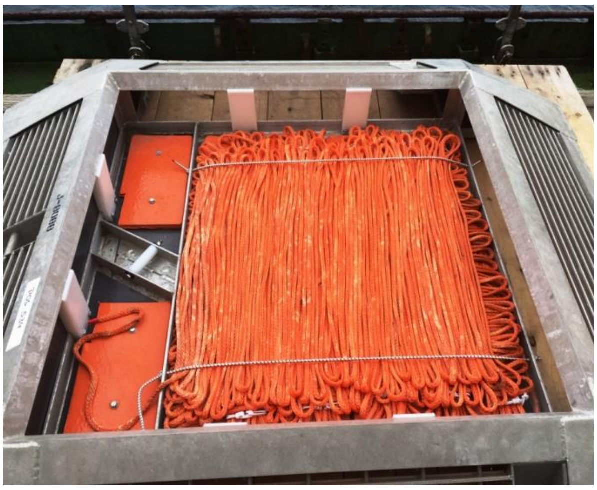


Fig. 5.7.1-2: *Anchoring base with coated lead weights, Spectra line and attachment point for the releaser hock.*

Fig. 5.7.1-3: *Floatation unit with ADCP and remote releaser hydrophone mounted on top of the anchoring base.*

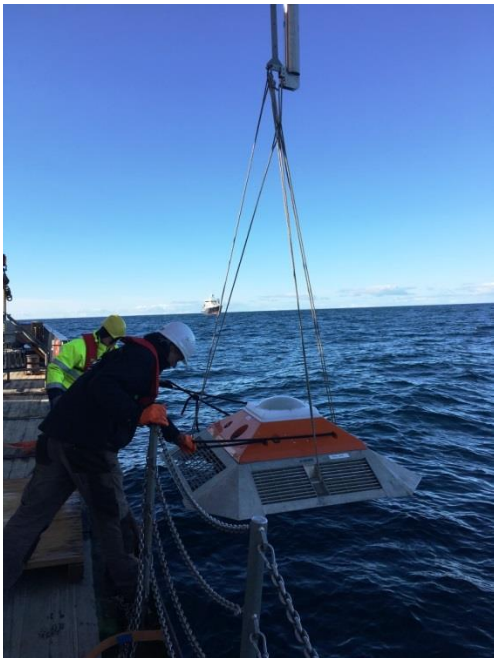
Fig. 5.7.1-4: *Anchoring base with frame for the floatation unit and acoustic release with remote hydrophone placed on top of the line. In front the second acoustic releaser for deployment.*

The targeted deployment of the lander was performed by a second acoustic release (RT661B1S, IXBLUE) attached to a rope for lowering the lander with the ship's winch close to the seafloor (Fig. 5.7.2-1).

The attached self-logging pH and pCO_2 optodes (University of Technology, Graz) are optical chemical sensors based on a fluorescent indicator dye immobilised on a polymer layer that changes its fluorescence properties based on seawater pH or pCO_2 values. An LED light excites the dye molecule and the emitted light is guided by an optical fiber, captured and internally analysed by the device. These optodes measure and record data autonomously and they are ideal for long term deployment as they are able to log up to 10 million data with low power consumption. As pH and pCO_2 are strongly dependent on temperature, the device were calibrated under controlled temperature conditions. NaCl-Tris and NaCl-BisTris buffer solutions with an ionic strength of 0.7 µM and pH values of 8 and 7, respectively, were used for the calibration of the pH optode. The pCO_2 sensor was calibrated by increasing CO_2 concentrations via CO_2 gas bubbling. Calibration curves with measuring points bracketing the expected North Sea environmental values were obtained. Seawater reference materials from Dickson were used to assess the accuracy of the optodes. The sampling frequency of the optodes was set to 10 seconds in order to gain useful insights on the short term variability of pH and pCO_2.

5.7.2 Preliminary results

The lander was deployed from May 10th to May 25th covering the period before, during, and after the CO_2 release experiment. The deployment was about 150 m north-east of the CO_2 release experiment site (57˚ 59.841 N, 0˚ 22.295 W) at a water depth of 122 m.



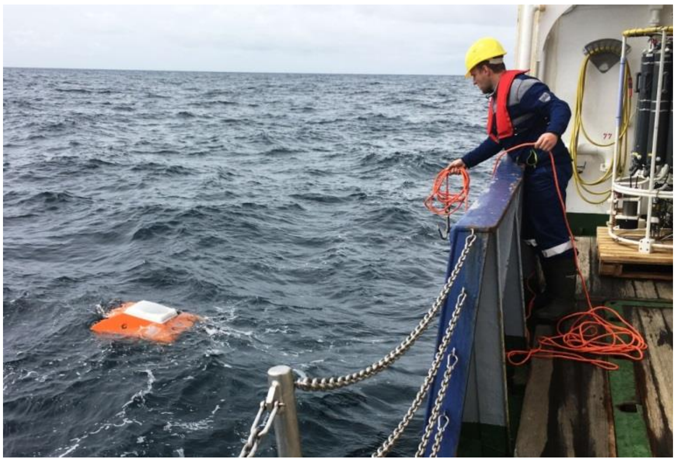


Fig. 5.7.2-1: *Deployment of the lander on a rope by acoustic release (left). CTD and sensors are hidden in the anchor base.*

Recovery of the floatation unit after acoustic release and detachment from the anchor base (above).

The first analysis of the ADCP data depicts the tidal impact and the impact of the weather on the current velocity and direction (Fig. 5.7.2-2, -3).

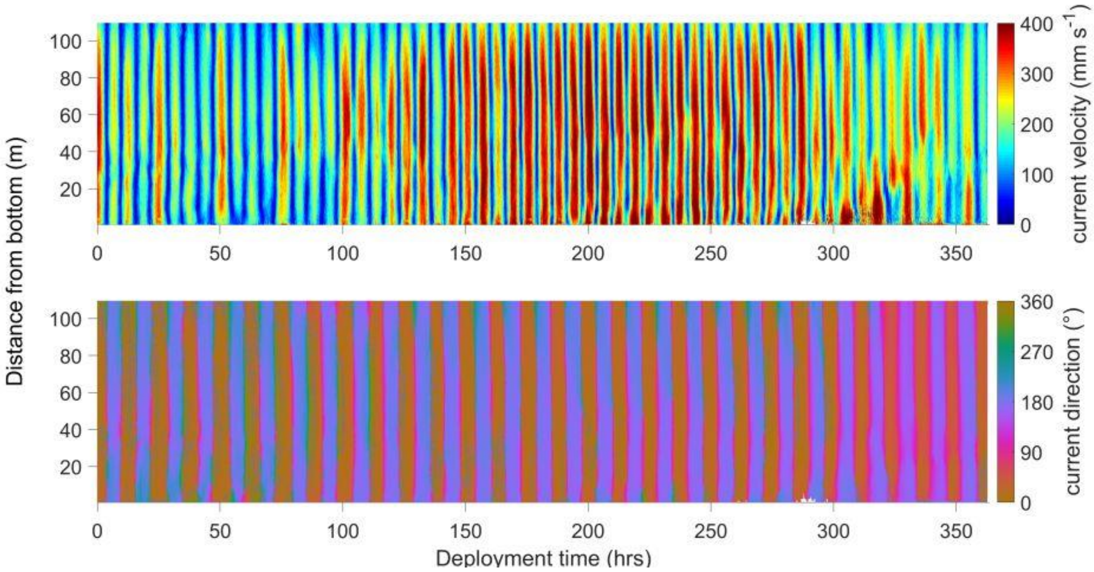


Fig. 5.7.2-2: *Lander ADCP data: Current velocity magnitude in mm/s (upper panel) and direction (lower panel).*

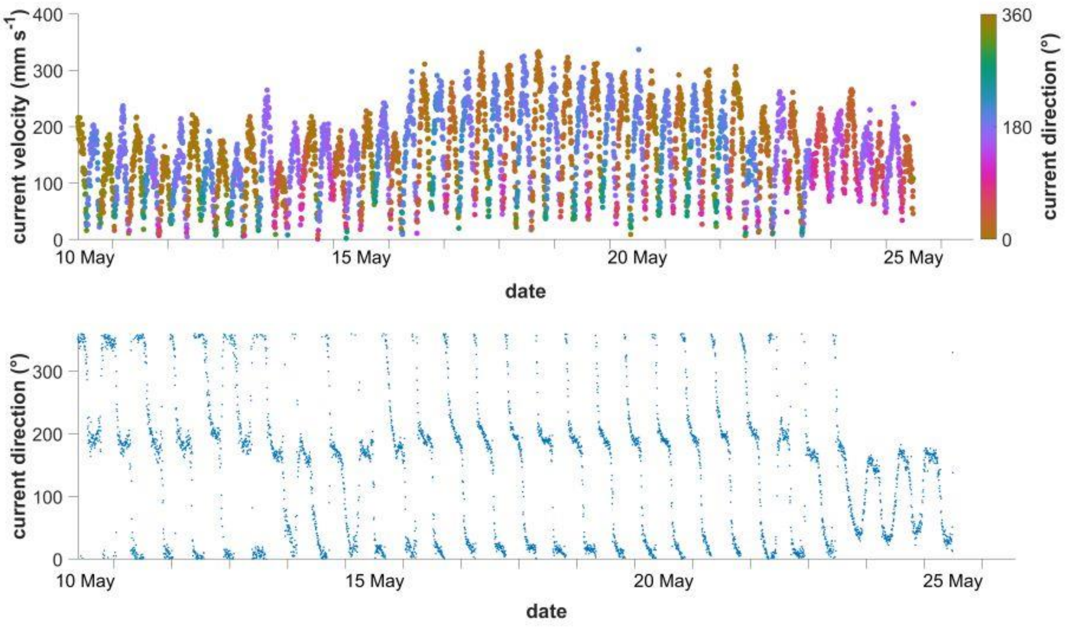


Fig. 5.7.2-3: *Lander ADCP data in approx. 4 m above seafloor: Current velocity magnitude in mm/s with current direction (upper panel) and direction (lower panel).*

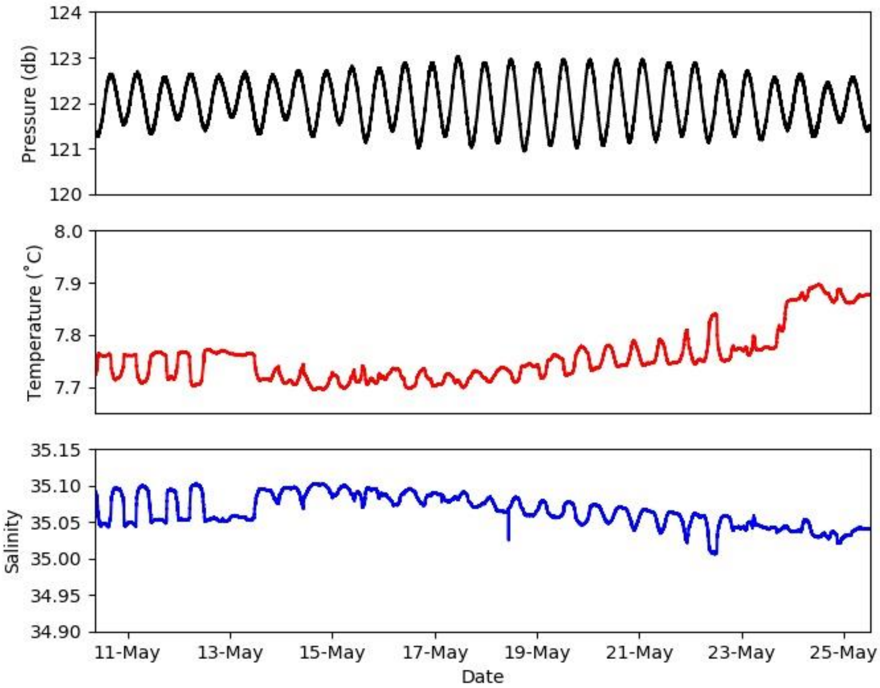


Fig. 5.7.2-4: *CTD data from the benthic lander deployment on POS534.*

Data from the benthic lander deployment show a clear tidal variation of salinity and temperature values (Fig. 5.7.2-4). Over a tidal cycle, temperature variations were between 0.05 ˚C while salinity varied of about 0.05 psu units. Preliminary results from the pH- and pCO2-optode are plotted versus time (Fig. 5.7.2-5).

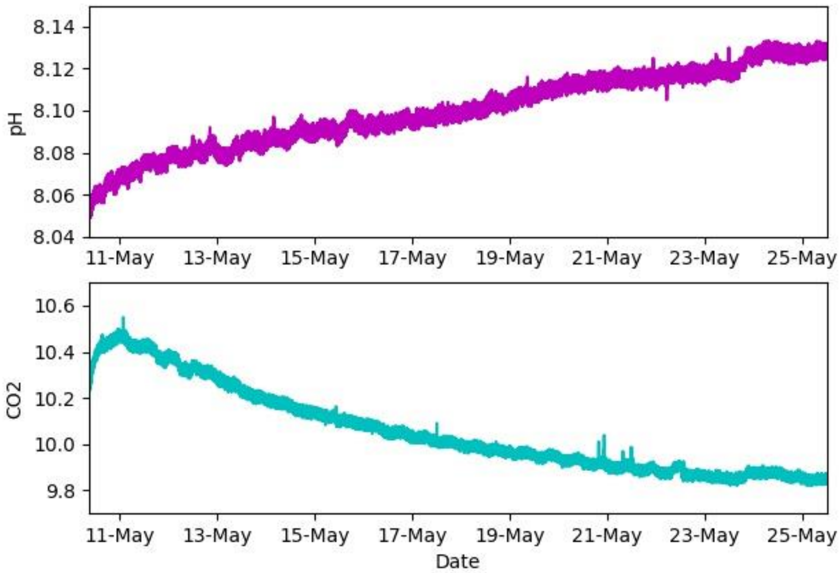


Fig. 5.7.2-5: *Preliminary pH and CO2 results from optodes deployed on the benthic lander during POS534*

The graph indicates a general increase in pH (from 8.06 to 8.12) and a corresponding decrease in CO_2 (from 10.4 to 9.9 µM) with time over the whole deployment. Values are within natural variability and no effect from the CO_2 released at the experiment site can be observed. A closer look at the measurements reveals the effect of tides on the pH and CO_2 values (Fig. 5.7.2-6).

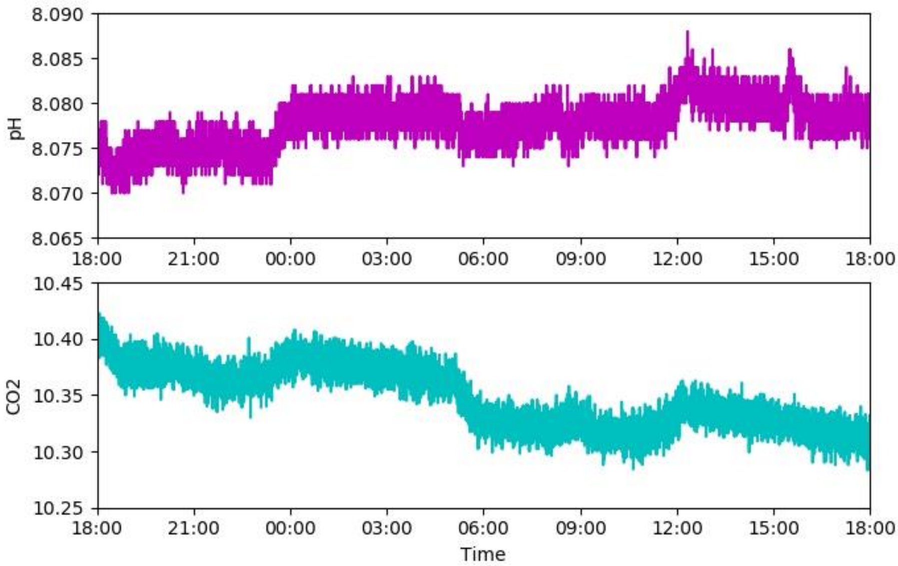


Fig. 5.7.2-6: *Section of preliminary pH and CO_2 values from optodes deployed on the benthic lander during POS534. Measurements are from May 11th at 18:00 UTC to May 12th at 18:00 UTC.*

Tidal variation of 0.01 units and 0.1 µM were observed for pH and CO_2, respectively. Overall, the deployment of the pH and pCO_2 optodes on the benthic lander was successful and proved the loggers capability to detect subtle variations in water properties over short and long term periods.

5.8 HydroC flow-through gas sensors

J. Triest

KM Contros HydroC Flow-Through (FT) sensors were installed and operated in the wet lab for most of the duration of the Leg 1 (Fig. 5.8-1). The sensors were connected to the same pumped water flow as the onboard mobile Membrane Inlet Mass spectrometer and the underway HydroFIA-TA system to determine the dissolved carbon system of surface water and deeper water column (i.e. pCO_2, Total Alkalinity). Two valves and a bypass system were used to control the flow to the FT sensors at 7 L/min whether the water was pumped from the surface or towed Video-CTD.

The datafiles that have been obtained for the stations of Leg 1 are listed in the Table 5.8.1 below.

Fig. 5.8-1: *Overview of the flow-through (FT) setup in the wet-lab. The two (orange) valves were used to control the direction and flow rate of the pumped water.*

In addition to the standard FT sensors that were used for scientific data recording there was also some R&D with proto-type sensors and the main objectives for these measurements were:

- the comparison of the results between the onboard FT-sensors using the pumped water and the in-situ sensors on the VCTD
- evaluate the effects of biofouling
- inter-comparison between sensors with PDMS and Teflon membranes
- experiments with fast-response sensors and equilibrator and membrane performance

Table 5.8.1: *Overview of the HydroC datafiles recorded for the stations of Leg 1.*

Cruise #	Leg #	Station #	Location	FT files	HydroC files	VCTD files
POS534	1	1	VCTD Modem test	na	na	VCTD01.cnv
POS534	1	2	Stolker Grund Profile	na	na	na
POS534	1	3	Hydroacoustic	na	na	na
POS534	1	4	Hydroacoustic	na	na	na
POS534	1	5	Hydroacoustic	na	na	na
POS534	1	6	Hydroacoustic	na	na	na
POS534	1	7	Hydroacoustic	na	na	na
POS534	1	8	Hydroacoustic	na	na	na
POS534	1	9	Hydroacoustic	na	na	na
POS534	1	10	Norwegian wells	datafile_20190508_103551 Norwegian well VCTD cast.txt	SD_datafile_20190509_081111CH4P-0515-001.txt	VCTD02B-2.cnv
				Flow data Norwegian well VCTD cast.txt	SD_datafile_20190509_081111CH4P-0515-001_raw.txt	VCTD02B-2_1sec.cnv
					SD_datafile_20190509_083834CH4P-1214-005.txt	
					SD_datafile_20190509_083834CH4P-1214-005_raw.txt	
					SD_datafile_20190509_090158CO2T-0718-001.txt	
					SD_datafile_20190509_090158CO2T-0718-001_raw.txt	
					SD_datafile_20190509_092634CO2-0119-001.txt	
					SD_datafile_20190509_092634CO2-0119-001_raw.txt	
POS534	1	11	Shield Lander deployment	na	na	na
POS534	1	12	Goldeneye	na	SD_datafile_20190510_183936CO2-0119-001.txt	VCTD03.cnv
					SD_datafile_20190510_183936CO2-0119-001_raw.txt	VCTD03_1s.cnv
					SD_datafile_20190510_190138CO2T-0718-001.txt	VCTD03B.cnv
					SD_datafile_20190510_190138CO2T-0718-001_raw.txt	VCTD03B_1s.cnv
					SD_datafile_20190510_192915CH4P-1214-005.txt	
					SD_datafile_20190510_192915CH4P-1214-005_raw.txt	
					SD_datafile_20190510_195705CH4P-0515-001.txt	
					SD_datafile_20190510_195705CH4P-0515-001_raw.txt	
POS534	1	13	Track around Goldeneye	tbc	na	
POS534	1	14	East of Goldeneye	datafile_20190511_070749 Background survey East tidal cycle 1105.txt	SD_datafile_20190511_183132CO2-0119-001.txt	VCTD04.cnv
				Flow data Background survey East tidal cycle 1105.tx	SD_datafile_20190511_183132CO2-0119-001_raw.txt	
					SD_datafile_20190511_185012CO2T-0718-001.tx	
					SD_datafile_20190511_185012CO2T-0718-001_raw.tx	
					SD_datafile_20190511_191305CH4P-1214-005.txt	
					SD_datafile_20190511_191305CH4P-1214-005_raw.txt	
					SD_datafile_20190511_193501CH4P-0515-001.tx	
					SD_datafile_20190511_193501CH4P-0515-001_raw.tx	
POS534	1	15	South of Goldeneye	tbc	SD_datafile_20190512_180109CO2T-0718-001.txt	VCTD05.cnv
					SD_datafile_20190512_180109CO2T-0718-001_raw.txt	VCTD05B.cnv
					SD_datafile_20190512_183204CO2-0119-001.txt	
					SD_datafile_20190512_183204CO2-0119-001_raw.txt	
					SD_datafile_20190512_190248CH4P-1214-005.tx	
					SD_datafile_20190512_190248CH4P-1214-005_raw.tx	
POS534	1	16	Goldeneye	datafile_20190513_084329 Water column profile morning 1305.tx	SD_datafile_20190513_125728CO2-0119-001.txt	VCTD06_1s.cnv
				Flow data Water column profile morning of 1305.txt	SD_datafile_20190513_125728CO2-0119-001_raw.txt	VCTD06B_1s.cnv
					SD_datafile_20190513_131229CO2T-0718-001.txt	VCTD06C_1s.cnv
					SD_datafile_20190513_131229CO2T-0718-001_raw.txt	
					SD_datafile_20190513_133248CH4P-1214-005.txt	
					SD_datafile_20190513_133248CH4P-1214-005_raw.txt	
POS534	1	17	Goldeneye	datafile_20190513_192606 Night VCTD from 13-1405.tx	SD_datafile_20190514_121442CO2-0119-001.txt	VCTD07_1s.cnv
				Flow data Night VCTD 13-1405.txt	SD_datafile_20190514_121442CO2-0119-001_raw.txt	VCTD07B_1s.cnv
					SD_datafile_20190514_123828CO2T-0718-001.txt	
					SD_datafile_20190514_123828CO2T-0718-001_raw.txt	
					SD_datafile_20190514_132014CH4P-1214-005.txt	
					SD_datafile_20190514_132014CH4P-1214-005_raw.txt	
POS534	1	18		na	na	
POS534	1	19		na	na	
POS534	1	20		na	na	
POS534	1	21		na	na	
POS534	1	22		na	na	
POS534	1	23		datafile_20190515_085157 Well survey with sled morning of 1505.txt	datafile_20190515_084912 Well with sled morning of 1505.txt	
				Flow data Well survey with sled morning of 1505.tx		

POS534	1	24		datafile_20190515_122139 Well survey with sled afternoon of 1505.txt	datafile_20190515_111900 Well survey with sled afternoon of 1505.txt	na
				Flow data Well survey with sled afternoon of 1505.txt		
POS534	1	25				
POS534	1	26				
POS534	1	27				
POS534	1	28				
POS534	1	29	14/29-A4	datafile_20190516_084845 All day surface water on 1605.txt	SD_datafile_20190516_091641CO2T-0718-001.txt	na
				Flow data All day surface water on 1605.txt	SD_datafile_20190516_091641CO2T-0718-001_raw.txt	
					SD_datafile_20190516_093115CH4P-0515-001.txt	
					SD_datafile_20190516_093115CH4P-0515-001_raw.txt	
POS534	1	30	Goldeneye	datafile_20190516_201036 Release site survey two night of 16-1705.tx	SD_datafile_20190517_143416CO2-0119-001.txt	VCTD08_1s.cnv
				Flow data Release site survey night 16-1705.txt	SD_datafile_20190517_143416CO2-0119-001_raw.txt	
					SD_datafile_20190517_145650CO2T-0718-001.txt	
					SD_datafile_20190517_145650CO2T-0718-001_raw.txt	
					SD_datafile_20190517_152805CH4P-1214-005.txt	
					SD_datafile_20190517_152805CH4P-1214-005_raw.txt	
POS534	1	31	Goldeneye SW depression	na	na	na
POS534	1	32	Goldeneye SW depression	na	SD_datafile_20190518_120102CO2-0119-001.txt	VCTD09_1s.cnv
					SD_datafile_20190518_120102CO2-0119-001_raw.txt	
					SD_datafile_20190518_122313CO2T-0718-001.txt	
					SD_datafile_20190518_122313CO2T-0718-001_raw.txt	
					SD_datafile_20190518_181909CH4P-1214-005.txt	
					SD_datafile_20190518_181909CH4P-1214-005_raw.txt	
POS534	1	33	Goldeneye SW depression	na	SD_datafile_20190518_180914CO2-0119-001.txt	VCTD10_1s.cnv
					SD_datafile_20190518_180914CO2-0119-001_raw.txt	
					SD_datafile_20190518_170228CO2T-0718-001.txt	
					SD_datafile_20190518_170228CO2T-0718-001_raw.txt	
					SD_datafile_20190518_181909CH4P-1214-005.txt	
					SD_datafile_20190518_181909CH4P-1214-005_raw.txt	
POS534	1	34	Goldeneye SW depression	na	SD_datafile_20190519_125752CO2-0119-001.txt	VCTD11_1s.cnv
					SD_datafile_20190519_125752CO2-0119-001_raw.txt	VCTD11B_1s.cnv
					SD_datafile_20190519_122526CO2T-0718-001.txt	
					SD_datafile_20190519_122526CO2T-0718-001_raw.txt	
					SD_datafile_20190519_131842CH4P-1214-005.txt	
					SD_datafile_20190519_131842CH4P-1214-005_raw.txt	
POS534	1	35	Goldeneye	datafile_20190519_191500 Overnight release site survey 19-2005.txt	SD_datafile_20190520_143309CH4P-01214-005.txt	VCTD012_1s.cnv
				Flow data Overnight release site survey 19-2005.txt	SD_datafile_20190520_143309CH4P-01214-005_raw.txt	
					SD_datafile_20190520_160354CO2-0119-001.txt	
					SD_datafile_20190520_160354CO2-0119-001_raw.txt	
					SD_datafile_20190520_162129CO2-0412-005.txt	
					SD_datafile_20190520_162129CO2-0412-005_raw.txt	
					SD_datafile_20190520_163925CO2T-0718-001.txt	
					SD_datafile_20190520_163925CO2T-0718-001_raw.txt	

5.9 Flow-through MIMS

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A Membrane Inlet Mass Spectrometer (MIMS) was used to measure dissolved gas concentrations of pumped seawater from depth. The flow-through line connected the towed Video-CTD (Fig. 5.4-1) with the membrane inlet of the mass spectrometer in the onboard wet laboratory (Fig. 5.9-1). The MIMS designed at GEOMAR combines a dual inlet pumped by membrane pump with a high vacuum turbo molecular pumped mass filter (0-150 Dalton ion trap, Granville Phillips; Fig. 5.9-2). Software designed at GEOMAR and from Granville Phillips was combined to control the MIMS and to record all data (Figs 5.9-2 and 3).
The MIMS was permanently operated during all pumped Video-CTD stations (Table 5.6.1-1). Additionally, calibration procedures of the mass spectrometer were conducted after each towed VCTD station with seawater, equilibrated with 1000 and 2500 ppm CO_2, respectively.

Fig. 5.9-1: *Mobile Membrane Inlet Mass Spectrometer (GEOMAR) including accessories kit for calibration was build up on the left side of the central table in the wet laboratory of RV Poseidon.*

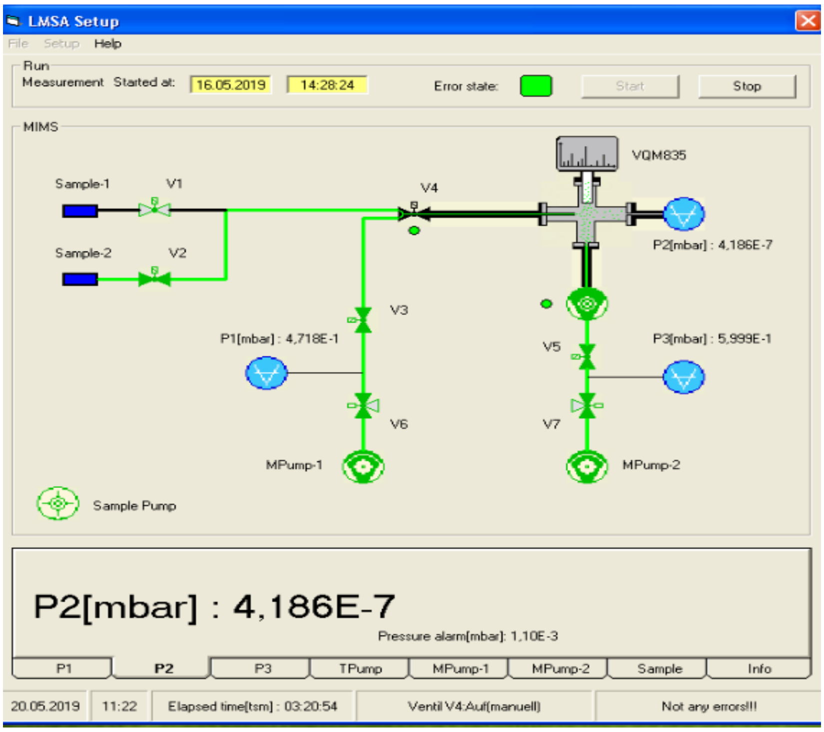
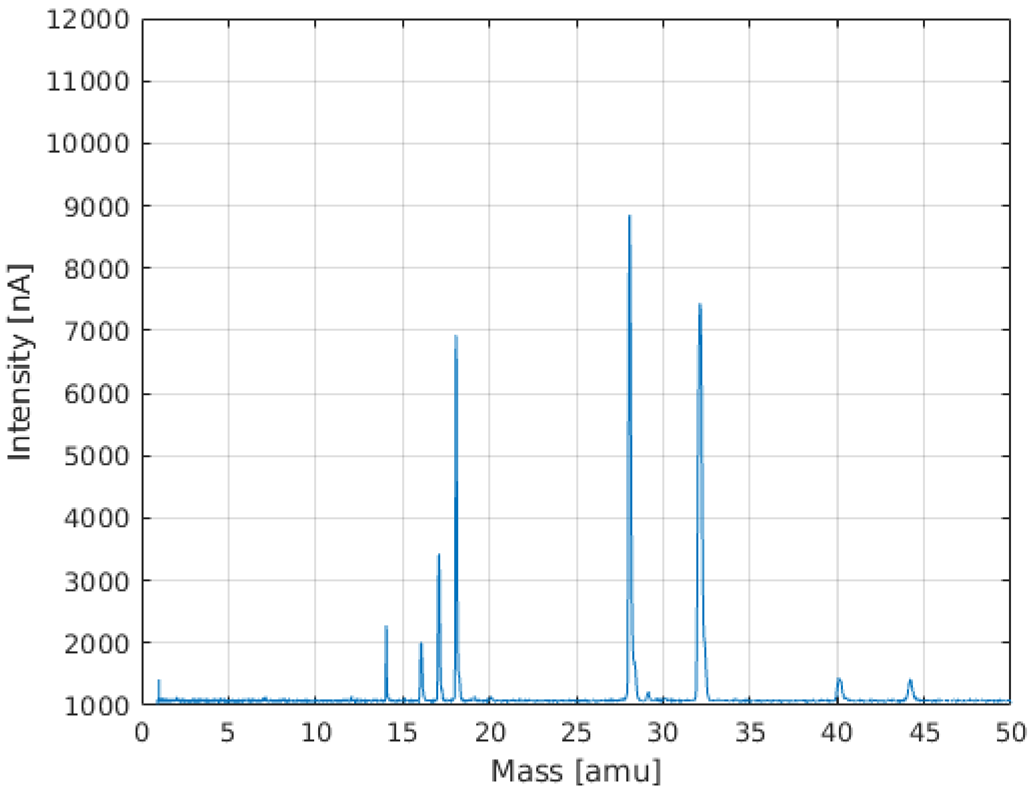


Fig. 5.9-2: *Control panel of the mobile MIMS visualized by software programmed with Visual Basics.*



5.9-3: *Dissolved gas data monitored by the mass spectrometer are recorded with Granville Phillips software package, i.e. a typical mass spectrum recorded during near-seafloor VCTD12 track, in the vicinity of the CO_2-release site is plotted.*

5.10 Sediment biogeochemistry

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5.10.1 Sediment coring methodology

On Leg 2, sampling of sediments for geological and geochemical analyses of the sediment around the CO_2 release site was carried out with a gravity corer (GC) and a multi corer (MUC). Due to stormy weather with high waves at the beginning of leg 2, the time on site was limited to one day. Coring took place between the afternoon of May 25th and the afternoon of May 26th. The cores were taken around the turn of tide to minimize the effect of the tide currents. Table 5.10.1-1 lists the coordinates of the collected cores.

Gravity coring

The GC was equipped with a weight of 1150 kg and a 5-m long core barrel. It was deployed at the Goldeneye CO_2 release site at a water depth of 117 m. The challenge was to hit the rather small CO_2 emission site without video guidance and without dynamic positioning of the vessel. For a more exact positioning, the corer was initially lowered to 80 m water depth. Then, the ship's position was corrected manually and the corer was lowered the remaining distance into the sea floor. Core retrieval was between 405 and 430 cm for all measured cores.

After the retrieved GCs were on deck, 2 of the GCs were selected for geochemical analyses on each sampling day, resulting in 4 analyzed GCs in total. The inner plastic liner (inner diameter of 110 mm) was pulled out and cut into 1-m long segments, which were each cut lengthwise into a sampling and an archive half. The working half was processed in the ship's wet lab. Sediment samples for porosity analysis and the quantification of adsorbed methane were taken and pore water was retrieved from 2 cm thick core sections using a pore water press. A total of 53 samples were taken from the 4 GCs. After sediment sampling, measurements with a SBE27 pH/ORP electrode were carried out in the remaining split sediment cores. The electrode was placed 4 cm below each sediment sample location and pH value as well as temperature were logged. Subsequently, the sampling and the archive half were transferred into D-tubes for long-term storage at GEOMAR's cooled core repository. The remaining 6 GCs were cut into 1-m long segments and stored for geomechanical analyses and for experiments of project partners. Only sections with a length of ~1 meter were stored. The small 10 – 30 cm long sections from the top of the cores were discarded.

Multiple coring

The MUC is equipped with 6 Perspex liners 60 cm long and with an internal diameter of 10 cm. The coring procedure for the MUC was similar to the coring procedure for the GCs. Once on the seafloor, the liners were pushed into the sediment under gravity by a set of lead weights. The length of the recovered sediment was about 30 cm. Recovered sediments were immediately processed on board. Due to time constraints, pore water was retrieved from only 7 sections per MUC with a thickness of 2 cm (MUC1) and 3 cm (MUC2). Sediment samples for porosity determination were taken from a different MUC liner than the pore water samples.

After the stop of the coring operation, a video survey of the area was done from board of the RRS James Cook. From the survey data, it looks as though one set of gravity cores were taken to the northwest of the main experiment area, 3-5 meters away. The multi cores were five meters to the northwest and another set of gravity cores were on the 7 meter mark to the northwest.

Table 5.10.1-1: *Position of gravity cores and multi cores (coordinates indicate ship's GPS position).*

Ship Station	***Area***	***Latitude (N)***	***Longitude (W)***	***Water Depth /m***	***Device***	***Length of Core / cm***	***pore water analyses***	***number of samples***
56 GC1	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,678*	*0°22,456*	*117*	*GC*	*407*	*X*	*13*
57 GC2	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,681*	*0° 22,458*	*117*	*GC*		*-*	
58 GC3	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,679*	*0° 22,459*	*117*	*GC*	*429*	*X*	*14*
59 GC4	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,683*	*0° 22,462*	*117*	*GC*		*-*	
60 GC5	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,682*	*0° 22,457*	*117*	*GC*		*-*	
61 GC6	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,681*	*0° 22,447*	*117*	*GC*	*409*	*X*	*13*
62 GC7	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,680*	*0° 22,445*	*118*	*GC*		*-*	
63 GC8	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,683*	*0° 22,453*	*118*	*GC*		*-*	
64 GC9	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,683*	*0° 22,451*	*117*	*GC*		*-*	
65 GC10	*Goldeneye STEMM-CCS CO2 release site*	*57°59,683*	*0° 22,453*	*117*	*GC*	*420*	*X*	*13*
66 MUC1	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,666*	*0° 22,458*	*117*	*MUC*	*28*	*X*	*7*
67 MUC2	*Goldeneye STEMM-CCS CO_2 release site*	*57°59,673*	*0° 22,452*	*117*	*MUC*	*33*	*X*	*7*

5.10.2 Porewater sampling and analytical methods

The retrieved gravity cores were cut in half and 2 cm thick slices were taken in approximately 30 cm intervals. From the multi cores, sediment was extruded out of the plastic liners with a piston and cut into 1-2 cm thick slices. Subsequently, the pore water was extracted in the ship's wet lab at ambient temperature using a low pressure-squeezer (argon at 3-5 bar). While squeezing, the pore water was filtered through 0.2 µm cellulose acetate Whatman filters and collected in recipient vessels.

About 5 ml of wet sediment of each sediment slice was collected in small plastic cups for porosity analyses at GEOMAR. 3 ml of sediment were added to 20 ml headspace vials filled with 1.5 g NaCl and 9 ml of saturated NaCl solution. Vials were crimped with rubber stoppers and stored after mixing for further gas chromatographic and stable isotope measurements of headspace gas at GEOMAR.

Aliquots of the extracted pore water were sub-sampled for various onboard and further shore-based analyses. Subsamples for ICP-AES analysis were acidified with 20 µl of conc. suprapure

HNO_3 per 2 ml of pore water sample (i.e., pH < 1) and ~1.8 ml subsamples for $\delta^{13}C$, δD, $\delta^{18}O$ and DIC were treated with 10 µl of $HgCl_2$ to inhibit further microbial degradation. All samples for home-based analyses were stored refrigerated.

Analyses for the pore water solutes H_2S, NH_4^+, PO_4^{3-}, and SiO_4^{4-} were completed onboard using a Hitachi U-5100 spectrophotometer. The respective chemical analytics followed standard procedures (Grasshoff et al., 1999), i.e. hydrogen sulfide was measured as methylene blue, ammonium as indophenol blue, phosphate and silicate as molybdenum blue. Total alkalinity of the pore water was determined by titration with 0.02 N HCl using a mixture of methyl red and methylene blue as indicator. The titration vessel was bubbled with argon to strip any CO_2 and H_2S produced during the titration. The IAPSO seawater standard was used for calibration. Analytical precision and accuracy of each method are given in Table 5.10.2-1.

Tab. 5.10.2-1: *Accuracy of on board analytics.*

Chemical Parameter	**Analytical method**	**Detection limit**	**Analytical precision**	**Analytical accuracy**
NH_4^+	photometer	1 µmol/l	5 %	
PO_4^{3-}	photometer	1 µmol/l	5 %	
SiO_4^{4-}	photometer	5 µmol/l	2 %	
H_2S	photometer	3 µmol/l	3 %	
Alkalinity	titration	0.05 meq/l	3 %	4%

Geochemical analyses at the Goldeneye site have already been performed during the Poseidon POS 518 cruise in 2017. The aim of the current cruise was to retrieve actual pore water solute profiles of background cores and to check if the background profiles have changed over time, indicating that the biogeochemical fluxes and turnover rates had changed over time. Furthermore, it was intended to investigate the change in pore water profiles in cores that were taken at the CO_2 release site relative to cores from background sites.

A total of 67 samples from 4 gravity cores and 2 multi cores were processed on board. Preliminary results include all onboard analytics and the onshore porosity measurements. They are shown in Figure 5.10.2-1 to -3. For comparison, also the profiles for the gravity core POS518 14/2 GC2 are shown. These concentration profiles are related to position 57°59.648' N; 00°22.247' W which is near the actual CO_2 release site.

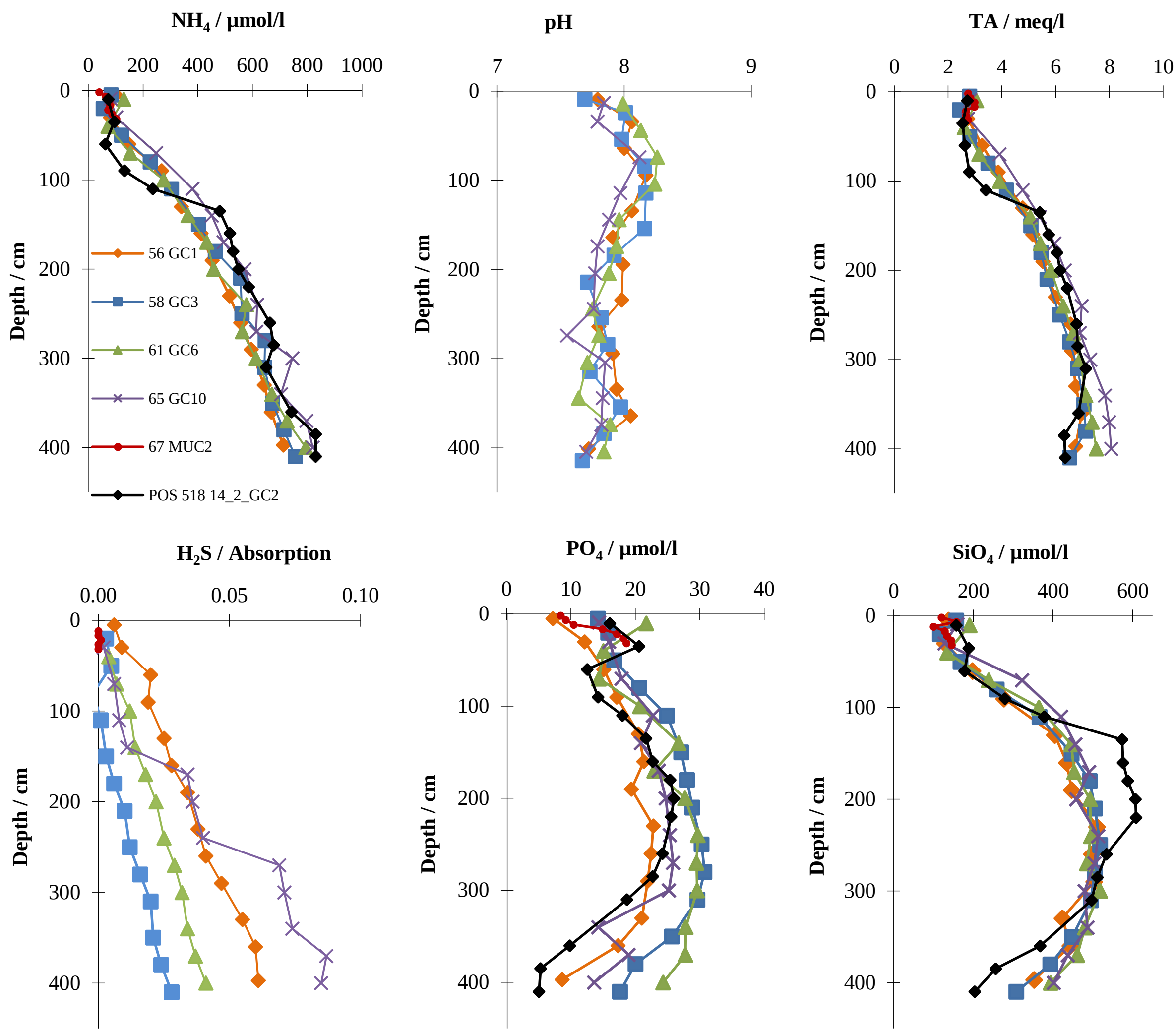

Fig. 5.10.2-1: *Pore water profiles of the concentrations of the nutrients NH_4^+, PO_4^{3-}, SiO_4^{4-}, absorption values for photo-spectrometric measurements of H_2S, total alkalinity values (TA) and pH values for the cores GC1, GC3, GC6, GC10, MUC2 and the Poseidon 518 core 14/2 GC2. GC data have not been adjusted for lost sediment.*

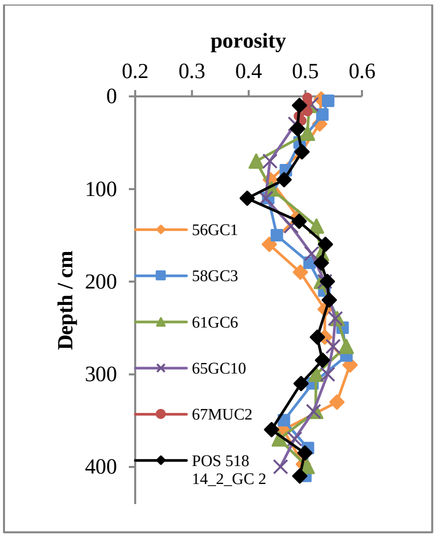

Fig. 5.10.2-2: *Porosity values for the cores GC1, GC3, GC6, GC10, MUC2 and the Poseidon 518 core 14/2 GC2. GC data have not been adjusted for lost sediment.*

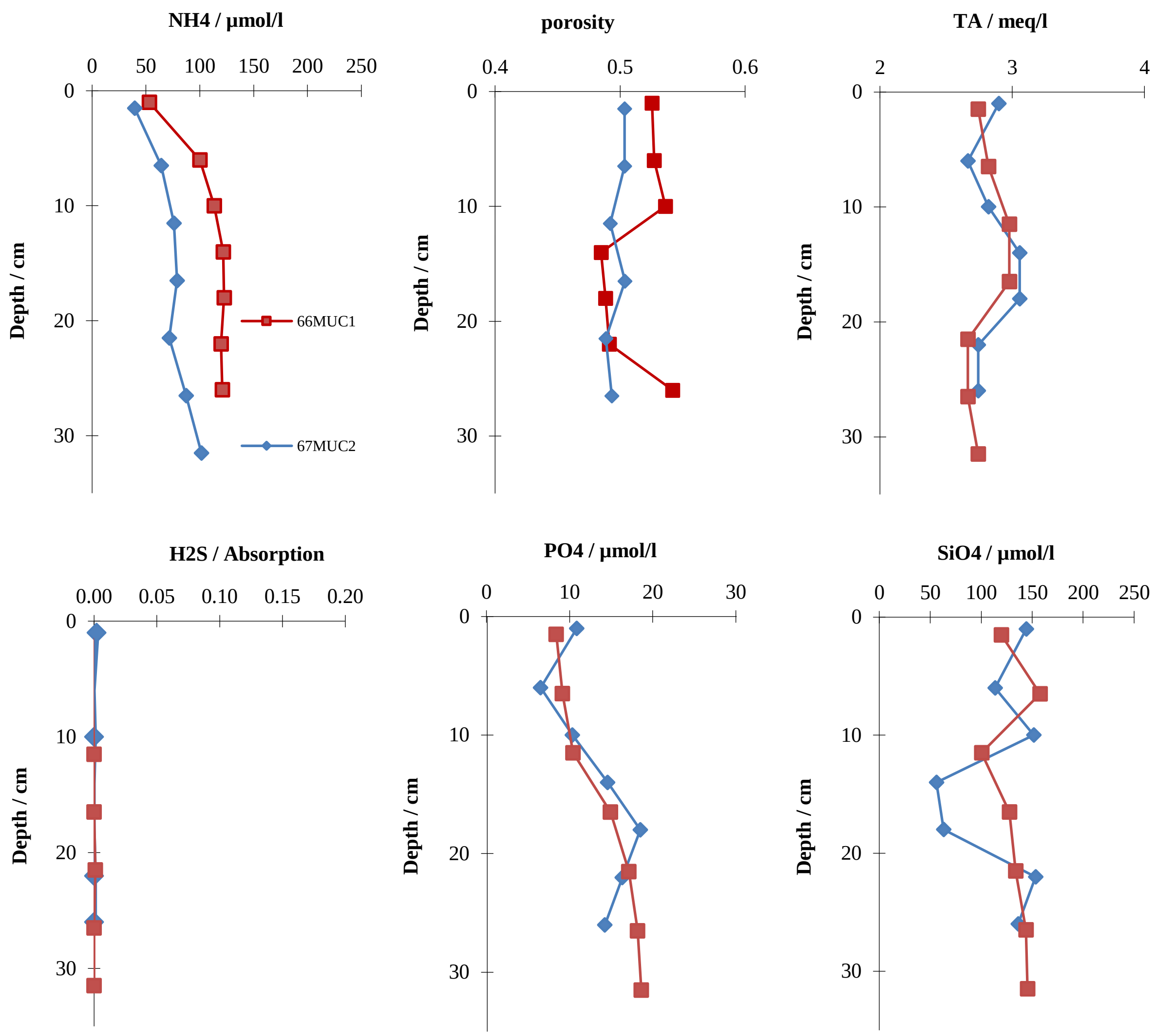

Fig. 5.10.2-3: *Pore water profiles of the concentrations of the nutrients NH_4^+, PO_4^{3-}, SiO_4^{4-}, absorption values for photo-spectrometric measurements of H_2S, total alkalinity values (TA) and porosity values for the cores MUC1 and MUC2.*

Photographs of the archive halves of the gravity cores GC1, GC3, GC6 and GC10 are shown in Figures 5.10.2-4 to -7. The sediment is mainly silty/clayey with some fine sands and an olive to brown color. Porosities vary between 0.4 and 0.55, which is typical for this type of sediment. The nutrient profiles and alkalinity profiles indicate regular organic matter degradation in the subsurface sediments. H_2S concentrations are slightly variable between cores, but generally low. No H_2S was detected in the multi cores. All other profiles are very similar and basically plot on top of each other. This also includes the core POS518 14/2 2, which was taken in 2017. We can therefore conclude that we see no change from background profiles in the preliminary data. pH values were comparable for all of the GCs. None of the cores showed a measurable decrease in pH or increase in alkalinity, which would be associated with an increased CO2 concentration in the pore water.

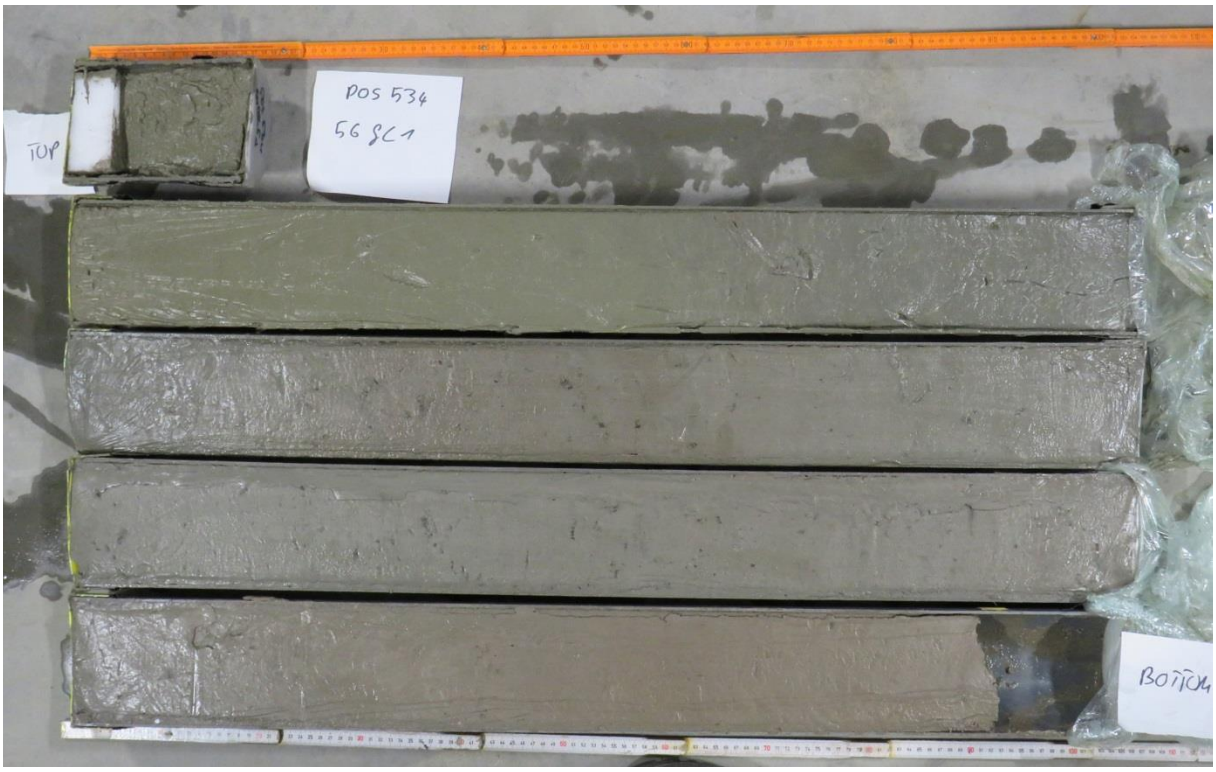

Fig. 5.10.2-4: *Archive halves of gravity core GC1.*

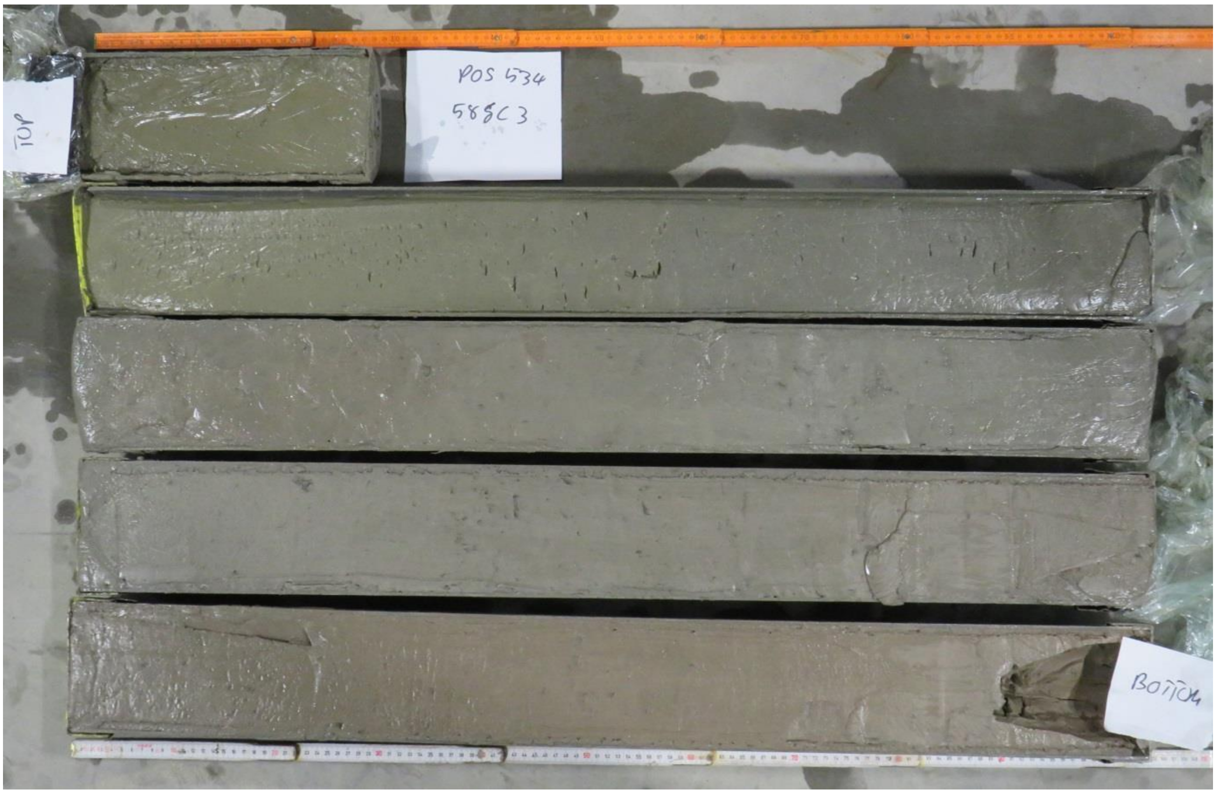

Fig. 5.10.2-5: *Archive halves of gravity core GC3.*

Fig. 5.10.1-6: *Archive halves of gravity core GC6.*

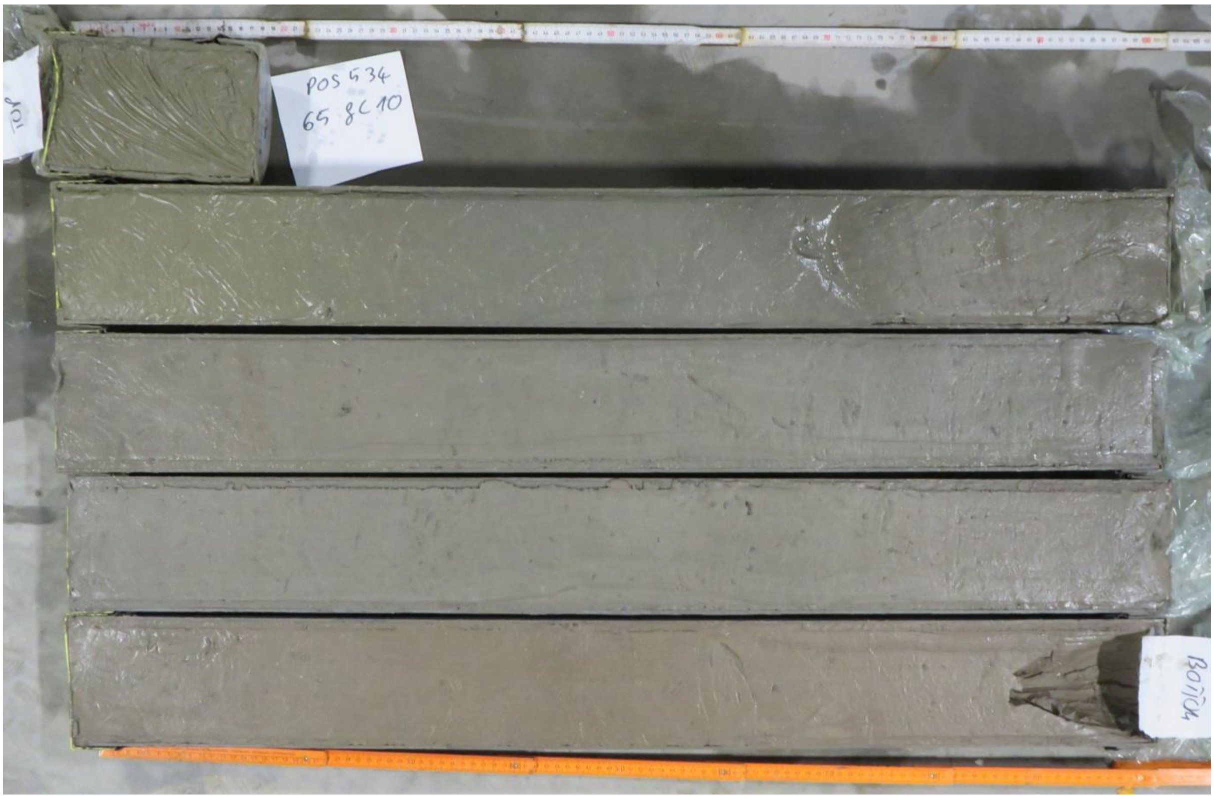

Fig. 5.10.2-7: *Archive halves of gravity core GC10.*

6 Station list POS534

Tab. 6-1: *Table summarizes start and end data of POS534 stations.*

Station	Date time (UTC)	Gear	Action	Latitude	Longitude	Water Depth (m)
POS534_1	01.05.2019 08:58	VCTD01	in the water	54° 29.409' N	010° 13.940' E	10.9
POS534_1	01.05.2019 09:11	VCTD	on deck	54° 29.415' N	010° 13.994' E	10.5
POS534_1	01.05.2019 09:29	VCTD01b	in the water	54° 29.395' N	010° 14.075' E	11.3
POS534_1	01.05.2019 09:38	VCTD	on deck	54° 29.401' N	010° 14.053' E	11
POS534_2	01.05.2019 10:37	ADCP/Echosounder01a	profile start	54° 29.176' N	010° 13.755' E	16.4
POS534_2	01.05.2019 13:47	ADCP/Echosounder	profile end	54° 29.253' N	010° 13.717' E	17.4
POS534_3	07.05.2019 19:53	ADCP/Echosounder01b	profile start	56° 16.495' N	003° 49.007' E	66.2
POS534_3	07.05.2019 20:19	ADCP/Echosounder	profile end	56° 16.235' N	003° 48.859' E	65.7
POS534_4	07.05.2019 22:28	ADCP/Echosounder02	profile start	56° 14.121' N	003° 37.892' E	68.5
POS534_4	07.05.2019 22:56	ADCP/Echosounder	profile end	56° 13.828' N	003° 37.715' E	68
POS534_5	08.05.2019 00:25	ADCP/Echosounder03	profile start	56° 10.880' N	003° 25.630' E	63.7
POS534_5	08.05.2019 00:52	ADCP/Echosounder	station end	56° 10.605' N	003° 25.580' E	65.2
POS534_6	08.05.2019 01:45	ADCP/Echosounder04	profile start	56° 14.654' N	003° 23.348' E	67.2
POS534_6	08.05.2019 02:09	ADCP/Echosounder	profile end	56° 14.816' N	003° 23.608' E	66.7
POS534_7	08.05.2019 02:34	ADCP/Echosounder05	profile start	56° 16.725' N	003° 22.350' E	68.7
POS534_7	08.05.2019 02:59	ADCP/Echosounder	profile end	56° 16.870' N	003° 21.912' E	69.5
POS534_8	08.05.2019 03:12	ADCP/Echosounder06	profile start	56° 17.677' N	003° 20.790' E	67.7
POS534_8	08.05.2019 03:37	ADCP/Echosounder	profile end	56° 17.759' N	003° 20.307' E	67.5
POS534_9	08.05.2019 04:03	ADCP/Echosounder07	profile start	56° 19.643' N	003° 18.547' E	66.2
POS534_9	08.05.2019 04:28	ADCP/Echosounder	profile end	56° 19.700' N	003° 18.150' E	67.5
POS534_10	08.05.2019 07:35	VCTD02a	in the water	56° 19.776' N	003° 18.433' E	67
POS534_10	08.05.2019 09:00	VCTD	max depth/on ground	56° 19.772' N	003° 18.445' E	67
POS534_10	08.05.2019 09:27	VCTD	on deck	56° 19.763' N	003° 18.448' E	66.7
POS534_10-2	08.05.2019 10:03	VCTD02b	in the water	56° 19.770' N	003° 18.438' E	65.7
POS534_10-2	08.05.2019 10:18	VCTD	max depth/on ground	56° 19.760' N	003° 18.434' E	66.5
POS534_10-2	08.05.2019 11:54	VCTD	on deck	56° 19.769' N	003° 18.415' E	67
POS534_11	10.05.2019 06:28	Releaser Test	in the water	57° 59.845' N	000° 22.295' W	116.7
POS534_11	10.05.2019 06:44	Releaser Test	on deck	57° 59.849' N	000° 22.273' W	117.7
POS534_11-2	10.05.2019 06:48	SHIELD Lander	in the water	57° 59.848' N	000° 22.278' W	118
POS534_11-2	10.05.2019 06:57	SHIELD Lander	deployed	57° 59.860' N	000° 22.280' W	117.7
POS534_12	10.05.2019 08:00	VCTD03 pumped	in the water	57° 59.493' N	000° 23.233' W	118
POS534_12	10.05.2019 08:41	VCTD	max depth/on ground	57° 59.555' N	000° 23.227' W	115.7
POS534_12	10.05.2019 08:43	VCTD	profile start	57° 59.556' N	000° 23.231' W	116.2

POS534_12	10.05.2019 14:48	VCTD	profile end	57° 59.406' N	000° 22.792' W	116.7
POS534_12	10.05.2019 14:59	VCTD	on deck	57° 59.299' N	000° 22.877' W	116.7
POS534_13	10.05.2019 16:07	ADCP/Echosounder08	profile start	57° 59.482' N	000° 23.251' W	117
POS534_13	10.05.2019 17:33	ADCP/Echosounder	profile end	57° 59.492' N	000° 23.264' W	117.7
POS534_14	11.05.2019 06:13	VCTD04 pumped	in the water	57° 59.996' N	000° 21.987' W	118
POS534_14	11.05.2019 06:59	VCTD	max depth/on ground	57° 59.999' N	000° 21.974' W	118.2
POS534_14	11.05.2019 15:03	VCTD	on deck	58° 00.388' N	000° 20.913' W	119.2
POS534_15	12.05.2019 06:18	VCTD05 pumped	in the water	57° 59.343' N	000° 22.608' W	117
POS534_15	12.05.2019 06:51	VCTD	max depth/on ground	57° 59.344' N	000° 22.636' W	116.2
POS534_15	12.05.2019 14:41	VCTD	on deck	57° 59.340' N	000° 22.628' W	115.2
POS534_16	13.05.2019 06:04	VCTD06 pumped	in the water	57° 59.709' N	000° 19.865' W	118.2
POS534_16	13.05.2019 06:47	VCTD	max depth/on ground	57° 59.682' N	000° 19.894' W	117.7
POS534_16	13.05.2019 09:28	VCTD	on deck	57° 59.670' N	000° 19.852' W	117.2
POS534_17	13.05.2019 16:44	VCTD07 pumped	in the water	57° 59.674' N	000° 22.462' W	117.2
POS534_17	13.05.2019 17:06	VCTD	max depth/on ground	57° 59.684' N	000° 22.452' W	115.7
POS534_17	13.05.2019 17:09	VCTD	information	57° 59.680' N	000° 22.448' W	116.2
POS534_17	14.05.2019 02:58	VCTD	on deck	57° 59.673' N	000° 22.467' W	118
POS534_18	14.05.2019 18:01	ADCP/Echosounder09	profile start	57° 48.260' N	000° 00.041' E	107
POS534_18	14.05.2019 18:22	ADCP/Echosounder	profile end	57° 48.186' N	000° 00.438' E	106.2
POS534_19	14.05.2019 18:57	ADCP/Echosounder10	profile start	57° 49.561' N	000° 06.518' E	108
POS534_19	14.05.2019 19:17	ADCP/Echosounder	profile end	57° 49.467' N	000° 06.912' E	108.2
POS534_20	14.05.2019 19:48	ADCP/Echosounder11	profile start	57° 46.736' N	000° 04.261' E	104.2
POS534_20	14.05.2019 20:09	ADCP/Echosounder	profile end	57° 46.528' N	000° 04.448' E	105.2
POS534_21	14.05.2019 20:20	ADCP/Echosounder12	profile start	57° 46.122' N	000° 03.142' E	102.2
POS534_21	14.05.2019 20:41	ADCP/Echosounder	profile end	57° 45.892' N	000° 03.176' E	104
POS534_22	14.05.2019 22:02	ADCP/Echosounder13	profile start	57° 40.915' N	000° 08.708' W	99.5
POS534_22	14.05.2019 22:25	ADCP/Echosounder	profile end	57° 40.697' N	000° 08.738' W	98.7
POS534_23	15.05.2019 07:07	OFOS/MIMS/WBAT01	in the water	57° 48.126' N	000° 00.161' E	106.5
POS534_23	15.05.2019 07:20	OFOS/MIMS/WBAT	max depth/on ground	57° 48.112' N	000° 00.175' E	106.2
POS534_23	15.05.2019 09:34	OFOS/MIMS/WBAT	on deck	57° 48.142' N	000° 00.196' E	106.7
POS534_24	15.05.2019 11:16	OFOS/MIMS/WBAT02	in the water	57° 49.624' N	000° 06.785' E	108.5
POS534_24	15.05.2019 11:47	OFOS/MIMS/WBAT	max depth/on ground	57° 49.633' N	000° 06.796' E	108.5
POS534_24	15.05.2019 15:08	OFOS/MIMS/WBAT	on deck	57° 49.698' N	000° 06.667' E	107.5
POS534_25	15.05.2019 17:14	ADCP/Echosounder14	profile start	57° 54.695' N	000° 15.820' E	132
POS534_25	15.05.2019 17:36	ADCP/Echosounder	profile end	57° 54.904' N	000° 15.974' E	132.5
POS534_26	15.05.2019 17:39	ADCP/Echosounder15	profile start	57° 55.045' N	000° 15.835' E	132.7
POS534_26	15.05.2019 18:02	ADCP/Echosounder15	profile end	57° 55.106' N	000° 15.427' E	131.7

POS534_27	15.05.2019 18:12	ADCP/Echosounder16	profile start	57° 55.693' N	000° 14.918' E	131.5
POS534_27	15.05.2019 18:34	ADCP/Echosounder	profile end	57° 55.699' N	000° 14.486' E	130.7
POS534_28	15.05.2019 20:00	ADCP/Echosounder17	profile start	57° 57.112' N	000° 30.339' E	140
POS534_28	15.05.2019 20:20	ADCP/Echosounder	profile end	57° 57.300' N	000° 30.524' E	139.5
POS534_29	16.05.2019 06:30	OFOS/MIMS/WBAT03	in the water	58° 00.048' N	000° 13.306' W	117.7
POS534_29	16.05.2019 06:40	OFOS/MIMS/WBAT	max depth/on ground	58° 00.034' N	000° 13.305' W	117.5
POS534_29	16.05.2019 09:06	OFOS/MIMS/WBAT	on deck	58° 00.001' N	000° 13.269' W	118.5
POS534_30	16.05.2019 18:03	VCTD08 pumped	in the water	57° 59.670' N	000° 22.465' W	118.5
POS534_30	16.05.2019 18:23	VCTD	max depth/on ground	57° 59.672' N	000° 22.493' W	118.5
POS534_30	17.05.2019 03:43	VCTD	on deck	57° 59.672' N	000° 22.466' W	118.5
POS534_31	17.05.2019 16:31	ADCP/Echosounder18	profile start	57° 59.292' N	000° 27.502' W	118.5
POS534_31	17.05.2019 17:34	ADCP/Echosounder	profile end	57° 59.001' N	000° 27.340' W	118.5
POS534_32	18.05.2019 07:03	VCTD09	in the water	57° 58.823' N	000° 27.916' W	118.5
POS534_32	18.05.2019 07:13	VCTD	max depth/on ground	57° 58.823' N	000° 27.916' W	118.5
POS534_32	18.05.2019 08:54	VCTD	on deck	57° 58.823' N	000° 27.900' W	118.5
POS534_33	18.05.2019 12:01	VCTD10	in the water	57° 58.821' N	000° 27.935' W	118.5
POS534_33	18.05.2019 12:12	VCTD	max depth/on ground	57° 58.822' N	000° 27.917' W	118.5
POS534_33	18.05.2019 14:50	VCTD	on deck	57° 58.837' N	000° 27.887' W	118.5
POS534_34	19.05.2019 06:31	VCTD11	in the water	57° 58.836' N	000° 27.898' W	118.5
POS534_34	19.05.2019 06:40	VCTD	max depth/on ground	57° 58.832' N	000° 27.914' W	118.5
POS534_34	19.05.2019 08:53	VCTD	on deck	57° 58.816' N	000° 27.918' W	118.5
POS534_35	19.05.2019 20:47	VCTD12 pumped	in the water	57° 59.729' N	000° 22.454' W	118.5
POS534_35	19.05.2019 21:14	VCTD	max depth/on ground	57° 59.734' N	000° 22.452' W	118.5
POS534_35	20.05.2019 04:46	VCTD	on deck	57° 59.691' N	000° 22.445' W	118.5
POS534_36	20.05.2019 04:53	ADCP/Echosounder19	profile start	57° 59.737' N	000° 22.483' W	118.5
POS534_36	20.05.2019 05:09	ADCP/Echosounder	profile end	57° 59.640' N	000° 22.355' W	118.5
POS534_37	20.05.2019 10:42	ADCP/Echosounder20	profile start	57° 40.115' N	000° 08.810' W	98.2
POS534_37	20.05.2019 11:01	ADCP/Echosounder	profile end	57° 39.974' N	000° 08.980' W	98.5
POS534_38	20.05.2019 13:37	ADCP/Echosounder21	profile start	57° 38.808' N	000° 20.215' E	99.2
POS534_38	20.05.2019 13:55	ADCP/Echosounder	profile end	57° 38.930' N	000° 20.361' E	99.7
POS534_39	20.05.2019 15:07	ADCP/Echosounder22	profile start	57° 45.031' N	000° 24.350' E	110.2
POS534_39	20.05.2019 15:24	ADCP/Echosounder	profile end	57° 45.102' N	000° 24.652' E	110.2
POS534_40	20.05.2019 17:54	ADCP/Echosounder23	profile start	57° 39.552' N	000° 50.897' E	114.7
POS534_40	20.05.2019 18:10	ADCP/Echosounder	profile end	57° 39.399' N	000° 51.014' E	114.5
POS534_41	20.05.2019 20:07	ADCP/Echosounder24	profile start	57° 33.945' N	000° 35.115' E	82.5
POS534_41	20.05.2019 20:28	ADCP/Echosounder	profile end	57° 33.715' N	000° 35.072' E	82.7
POS534_42	20.05.2019 21:02	ADCP/Echosounder25	profile start	57° 32.392' N	000° 40.087' E	80.7

POS534_42	20.05.2019 21:22	ADCP/Echosounder	profile end	57° 32.152' N	000° 40.175' E	80.5
POS534_43	20.05.2019 22:09	ADCP/Echosounder26	profile start	57° 28.864' N	000° 37.333' E	82.5
POS534_43	20.05.2019 22:34	ADCP/Echosounder	profile end	57° 28.830' N	000° 36.932' E	83
POS534_44	20.05.2019 23:48	ADCP/Echosounder27	profile start	57° 30.001' N	000° 25.957' E	85.2
POS534_44	21.05.2019 00:08	ADCP/Echosounder	profile end	57° 30.202' N	000° 25.725' E	85.7
POS534_45	21.05.2019 00:54	ADCP/Echosounder28	profile start	57° 32.674' N	000° 25.311' E	89.7
POS534_45	21.05.2019 01:16	ADCP/Echosounder	profile end	57° 32.864' N	000° 25.030' E	89.5
POS534_46	21.05.2019 01:56	ADCP/Echosounder29	profile start	57° 33.598' N	000° 18.375' E	89
POS534_46	21.05.2019 02:16	ADCP/Echosounder	profile end	57° 33.393' N	000° 18.252' E	88.2
POS534_47	21.05.2019 02:45	ADCP/Echosounder30	profile start	57° 30.885' N	000° 20.144' E	84
POS534_47	21.05.2019 03:08	ADCP/Echosounder	profile end	57° 30.699' N	000° 19.965' E	83.7
POS534_48	21.05.2019 03:39	ADCP/Echosounder31	profile start	57° 28.112' N	000° 18.445' E	79
POS534_48	21.05.2019 04:00	ADCP/Echosounder	profile end	57° 28.067' N	000° 18.046' E	78.7
POS534_49	21.05.2019 04:16	ADCP/Echosounder32	profile start	57° 27.764' N	000° 15.864' E	79
POS534_49	21.05.2019 04:37	ADCP/Echosounder	profile end	57° 27.812' N	000° 15.442' E	78.7
POS534_50	21.05.2019 05:32	ADCP/Echosounder33	profile start	57° 25.005' N	000° 07.875' E	88.5
POS534_50	21.05.2019 05:54	ADCP/Echosounder	profile end	57° 25.255' N	000° 07.735' E	88
POS534_51	21.05.2019 06:24	ADCP/Echosounder34	profile start	57° 27.843' N	000° 09.504' E	87.5
POS534_51	21.05.2019 06:44	ADCP/Echosounder	profile end	57° 28.038' N	000° 09.288' E	87.7
POS534_52	21.05.2019 06:47	ADCP/Echosounder35	profile start	57° 28.119' N	000° 08.891' E	88
POS534_52	21.05.2019 07:08	ADCP/Echosounder	profile end	57° 28.011' N	000° 08.511' E	87.7
POS534_53	21.05.2019 08:05	ADCP/Echosounder36	profile start	57° 31.249' N	000° 00.302' E	91.7
POS534_53	21.05.2019 08:26	ADCP/Echosounder	profile end	57° 31.192' N	000° 00.122' W	90.2
POS534_54	21.05.2019 09:05	ADCP/Echosounder37	profile start	57° 33.627' N	000° 04.567' W	96.5
POS534_54	21.05.2019 09:26	ADCP/Echosounder	profile end	57° 33.597' N	000° 04.997' W	96.7
POS534_55	25.05.2019 11:44	SHIELD lander	recovery	57° 59.834' N	000° 22.043' W	117.2
POS534_55	25.05.2019 11:47	SHIELD Lander	released	57° 59.840' N	000° 22.026' W	116
POS534_55	25.05.2019 12:13	SHIELD Lander	recovered	57° 59.943' N	000° 22.138' W	116.7
POS534_56	25.05.2019 13:27	Gravity corer01	in the water	57° 59.684' N	000° 22.440' W	116.7
POS534_56	25.05.2019 13:32	Gravity corer	max depth/on ground	57° 59.679' N	000° 22.457' W	116
POS534_56	25.05.2019 13:39	Gravity corer	on deck	57° 59.674' N	000° 22.453' W	117.2
POS534_57	25.05.2019 13:49	Gravity corer02	in the water	57° 59.681' N	000° 22.441' W	116.2
POS534_57	25.05.2019 13:57	Gravity corer	max depth/on ground	57° 59.681' N	000° 22.459' W	116
POS534_57	25.05.2019 14:02	Gravity corer	on deck	57° 59.683' N	000° 22.459' W	117
POS534_58	25.05.2019 14:11	Gravity corer03	in the water	57° 59.673' N	000° 22.453' W	117.2
POS534_58	25.05.2019 14:23	Gravity corer	max depth/on ground	57° 59.679' N	000° 22.459' W	116.7
POS534_58	25.05.2019 14:26	Gravity corer	on deck	57° 59.684' N	000° 22.456' W	117.2

POS534_59	25.05.2019 14:38	Gravity corer04	in the water	57° 59.686' N	000° 22.465' W	117.5
POS534_59	25.05.2019 14:40	Gravity corer	max depth/on ground	57° 59.682' N	000° 22.462' W	117.7
POS534_59	25.05.2019 14:44	Gravity corer	on deck	57° 59.684' N	000° 22.457' W	116.5
POS534_60	25.05.2019 14:56	Gravity corer05	in the water	57° 59.684' N	000° 22.464' W	116.5
POS534_60	25.05.2019 15:06	Gravity corer	max depth/on ground	57° 59.682' N	000° 22.456' W	117
POS534_60	25.05.2019 15:09	Gravity corer	on deck	57° 59.694' N	000° 22.445' W	117.2
POS534_61	26.05.2019 06:02	Gravity corer06	in the water	57° 59.673' N	000° 22.447' W	117.5
POS534_61	26.05.2019 06:08	Gravity corer	max depth/on ground	57° 59.682' N	000° 22.447' W	117
POS534_61	26.05.2019 06:12	Gravity corer	on deck	57° 59.678' N	000° 22.445' W	117.5
POS534_62	26.05.2019 06:24	Gravity corer07	in the water	57° 59.677' N	000° 22.442' W	117.7
POS534_62	26.05.2019 06:29	Gravity corer	max depth/on ground	57° 59.680' N	000° 22.445' W	117.2
POS534_62	26.05.2019 06:32	Gravity corer	on deck	57° 59.678' N	000° 22.445' W	117
POS534_63	26.05.2019 06:41	Gravity corer08	in the water	57° 59.684' N	000° 22.444' W	117.2
POS534_63	26.05.2019 06:45	Gravity corer	max depth/on ground	57° 59.683' N	000° 22.453' W	117.5
POS534_63	26.05.2019 06:48	Gravity corer	on deck	57° 59.684' N	000° 22.451' W	117
POS534_64	26.05.2019 06:56	Gravity corer09	in the water	57° 59.678' N	000° 22.454' W	117.5
POS534_64	26.05.2019 07:03	Gravity corer	max depth/on ground	57° 59.683' N	000° 22.451' W	117.2
POS534_64	26.05.2019 07:07	Gravity corer	on deck	57° 59.687' N	000° 22.455' W	117
POS534_65	26.05.2019 07:18	Gravity corer10	in the water	57° 59.677' N	000° 22.447' W	117
POS534_65	26.05.2019 07:22	Gravity corer	max depth/on ground	57° 59.682' N	000° 22.453' W	117.7
POS534_65	26.05.2019 07:27	Gravity corer	on deck	57° 59.681' N	000° 22.465' W	117.5
POS534_66	26.05.2019 13:05	Multi Corer01	in the water	57° 59.675' N	000° 22.460' W	116.5
POS534_66	26.05.2019 13:13	Multi Corer	max depth/on ground	57° 59.668' N	000° 22.460' W	116.7
POS534_66	26.05.2019 13:16	Multi Corer	on deck	57° 59.665' N	000° 22.461' W	116.2
POS534_67	26.05.2019 13:32	Multi Corer02	in the water	57° 59.666' N	000° 22.460' W	115.7
POS534_67	26.05.2019 13:39	Multi Corer	max depth/on ground	57° 59.673' N	000° 22.452' W	116
POS534_67	26.05.2019 13:43	Multi Corer	on deck	57° 59.673' N	000° 22.449' W	116.5
POS534_68	28.05.2019 11:06	VCTD13	in the water	54° 10.063' N	006° 58.024' E	31.2
POS534_68	28.05.2019 11:31	VCTD	max depth/on ground	54° 10.049' N	006° 58.039' E	2.1
POS534_68	28.05.2019 11:33	VCTD	profile start	54° 10.051' N	006° 58.040' E	33.2
POS534_68	28.05.2019 12:58	VCTD	profile end	54° 10.080' N	006° 58.099' E	32
POS534_68	28.05.2019 13:00	VCTD	on deck	54° 10.081' N	006° 58.107' E	32.2
POS534_69	28.05.2019 13:25	ADCP/Echosounder	profile start	54° 10.064' N	006° 58.035' E	33.1
POS534_69	28.05.2019 21:52	ADCP/Echosounder	profile end	54° 09.991' N	006° 58.176' E	39.1

7 Data and sample storage and availability

Physical samples taken during the expedition are stored at GEOMAR repositories and can be accessed on request. Local storage of sediment cores is provided by the GEOMAR lithothek, core and rock repository https://www.geomar.de/en/centre/central-facilities/tlz/core-rock-repository/.

Acquired hydroacoustic, video, and image raw data will be archived in the IT storage infrastructure at GEOMAR and is available on request.

All navigation, weather, echosounder, and surface water data recorded during POS534 is available for download at http://dship.geomar.de/

Short cruise summary report of the POS534 cruise including chart were made available 2 weeks after the cruise at the German Hydrographic Institute (BSH).under BSH Ref.-No 20190054: http://seadata.bsh.de/Cgi-csr/retrieve_sdn2/csrreport.pl?project=SDN&session=77423&v1=10&v2=1&pcode=06PO and https://www.bsh.de/EN/DATA/Oceanographic_Data_Center/Cruise_summary_reports/_Module/HTML/2019_node.html .

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