5. PHYSICAL OCEANOGRAPHY AND ASSOCIATED TASKS DURING MOSAIC LEG 4

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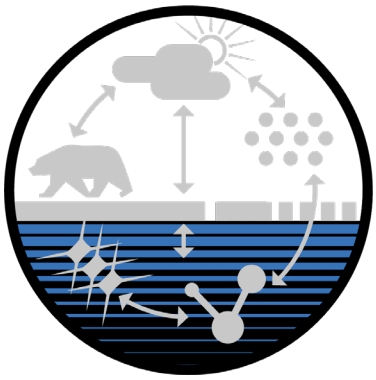

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A comprehensive summary of the physical-oceanographic measurements during all 5 cruise legs can be found in Rabe et al., 2022.

Background and Objectives

General physical oceanography of the central Arctic Ocean: brief specifics for leg 4

General background and objectives of the physical oceanography have been described in the expedition booklet, the report by Legs 1-3 and the individual proposals within team OCEAN. Here, we describe only the scientific motivation related to Leg 4, and the changes due to the interruption of the drift in detail.

With the start of the biological productive season, we planned to intensify the focus on turbulent mixing of the upper water column and the transport of nutrients, in collaboration with the ECO team. A new microstructure profiler with sensors for oxygen and chlorophyll-*a* was deployed. Furthermore, microstructure measurements of the near-surface boundary layer with the uprising VMP250 from UiB were intensified to investigate the dynamics of ice melt, and its effect on the upper ocean stratification and mixing.

Due to the COVID-19 Pandemic and the resulting logistical challenges, the plan of crew exchange via airplane from Svalbard had to be cancelled, and the drift with *Polarstern* was

interrupted in mid-May. *Polarstern* met with the two German research vessels *Sonne* and *Maria S. Merian* in front of Longyearbyen to exchange personnel and freight at sea. On Monday, June 8, cargo operations were finished and travel back north to the MOSAiC floe started in the afternoon.

Instrument maintenance and alterations

The transit time back to the floe was used for the maintenance of instruments, improvements and preparation, in summary: maintenance of *Polarstern* CTD (relocation PAR sensor for protection and fluorometer to have free measurement path, cleaning of transmissiometer, bottle repair, attaching a SBE35 high-precision temperature sensor, attaching the rhodamine sensor originally mounted on OC CTD) [IS,ST]; VMP250 software upgrade [MM]; building the new MSS091 into the housing of the malfunctioning MSS075 (which contained the MSS055 brought by IOW during Legs 2 and 3), and changing the baud rate of both of the AWI deck boxes [IS+KS]; the MSS cable on the 400m winch was found to be too short (~250m), was removed and replaced by ~450m cable from the former long (~1000m) cable. A broken connector cable from winch to deck unit was replaced with a spare [KS, IS].

Work at sea

Transit phase

After leaving the Norwegian EEZ in the late evening of 8 June, ship sensors (including the vessel mounted ADCP) were switched on. 9 June at 11:30, we reached the ice edge, and made good progress northward for the next days. In the afternoon of 11 June, the ice pressure increased and engines were stopped during the night. The next day, located above Yermak Plateau, a fishing rod CTD cast was performed (see Table 1).

On 16 June, a water column sampling station was performed close to the MOSAiC floe. We made a full water column CTD cast, at a water depth of 760m, including sampling for CFC, He, Tri, salinity, density and oxygen. Different from previous legs, team OCEAN (Ingo Schuffenhauer) took care of the analysis of dissolved oxygen samples. After the cast, the T-Pop70 was deployed, and another shallow (500m) CTD cast was performed for teams BGC and ECO.

The ice conditions on the MOSAiC floe did not allow for large infrastructure to be installed, as several deep meltponds and wet slush limited the use of snow machines. Furthermore, the proximity to the ice edge and the ongoing melting suggested that the measurement time on the MOSAiC floe will be rather in the order of weeks than months, and a repositioning further north might be necessary in the near future. We therefore decided to not rebuild the Ocean City setup with the weatherhaven, but to limit our infrastructure on the floe to the 75kHz Longranger ADCP, the 300kHz ADCP, and microstructure measurements with the MSS091 and the UiB VMP250 Upriser, so that we could start data collection as soon as possible. This meant that we did not have the small CTD rosette in Ocean City available, and neither the large NPI winch for LISST and net operations. Teams ECO and BGC fully supported this decision, and we chose to focus and rely on the ship CTD. See Figure 5.1 for a map of the Leg 4 MOSAiC Central Observatory. In the following, details on the deployment and configuration of all team OCEAN instruments and installations, as well as laboratory work, are summarized and the respective responsible persons on board are indicated.

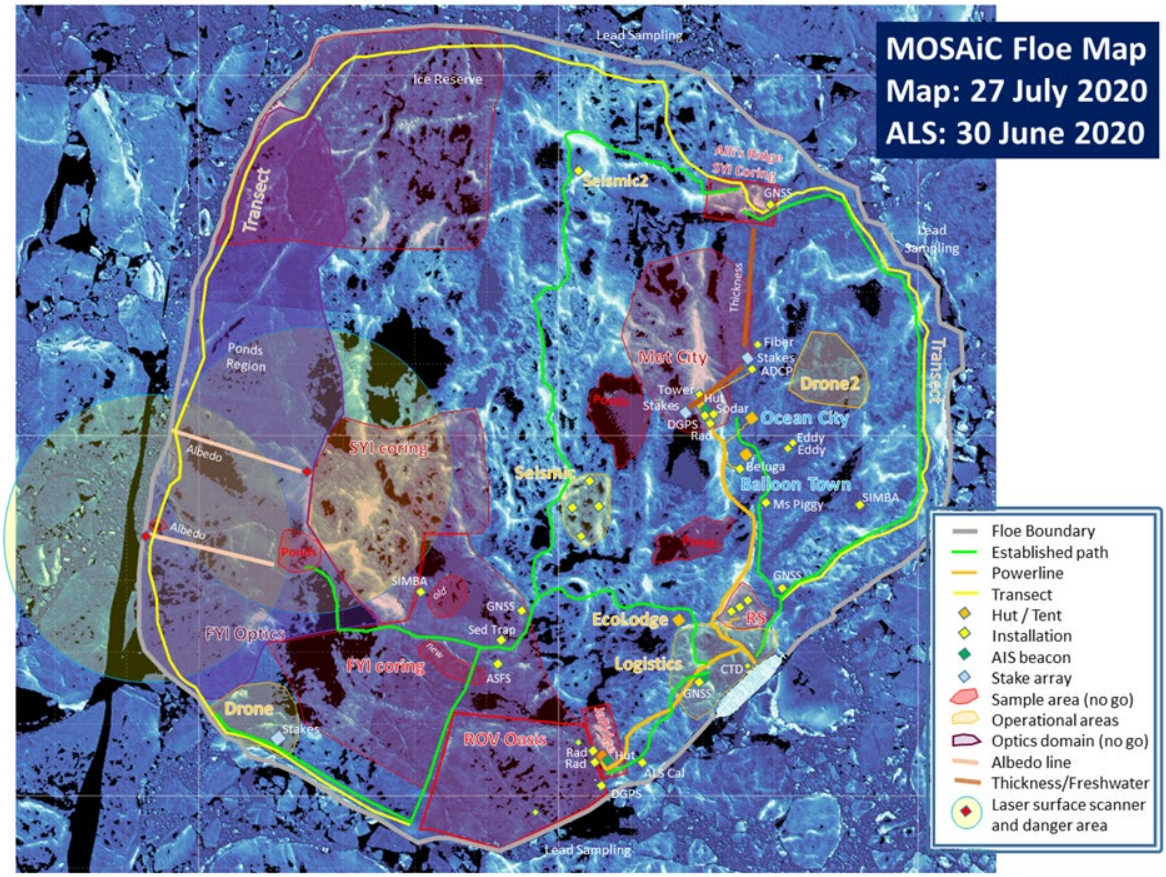

Fig. 5.1: ALS map of the MOSAiC Leg 4 Central Observatory Floe with all sites marked. Credit: AWI.

UiB 75kHz longranger ADCP [MM]

On Thursday, 25 June at 13:00 UTC (82 02.900N, 10 09.565E, depth: 983.6m), the UiB 75kHz Longranger ADCP was deployed in an icehole (made of several 10 inch auger holes on 22 June) approximately 80m “northeast” of Ocean City V2 (see Figure 5.1). The Longranger ADCP was connected to the power hub at the Met City hut and switches over to internal batteries when power is disconnected. Due to mobile ice conditions the ship is not attached to the floe anymore and therefore power supply is only sporadic. The Longranger was therefore configured to measure with averaged sampling in order to conserve power (“RDI75_20min_dep_leg4.txt”; Broadband (short range) to allow STD of about 1 cm/s with 60 pings; 20-min ensemble averages, 60x3s pings; 66x8m bins, broadband mode (short range); No blank distance (will exclude the first bin in post-processing); Record in beam coordinates, do not use tilt info or 3-beam solution; Tilt and 3-beam solutions will be addressed during post-processing). Since no data connection to the ship was established, the instrument was configured to store data internally. Data download is done weekly via direct serial connection to the ADCP and via USB to the GPS-compass logger, using the UiB semi-rugged laptop. The serial to Ethernet converter is disconnected. The 12V battery in the surface unit was replaced by a newer, but smaller one since the original battery is used at the UiB cluster mooring. During previous recovery, the ADCP cable was destroyed and therefore we replaced this with a spare RDI LADCP cable from AWI. The GPS compass was aligned with beam 3 of the instrument. During the initial deployment, the bar between the chains and the frame was slightly angled (see Figures 5.2 and 5.3), but we lifted up the instrument again to fix this and to make sure that beam 3 was aligned with the compass. The ice at the time of deployment was approximately 1.8m thick with a slushy surface layer of approximately 20cm.

On 29 July, the day before the final breakup of the floe, the 75kHz Longranger ADCP, together with the complete infrastructure on the floe, was recovered. Ice thickness during the time of recovery was approximately 60cm, and the ADCP hole had several drainage channels from the surrounding melt ponds. All data was successfully recovered and the full installation was prepared for re-installation at the new leg 5 floe.

Fig. 5.2: Deployment of the 75kHz ADCP by lowering it down with a skidoo (left, credit: Lianna Nixon) and a curious bear investigating the GPS compass only three hours after deployment (right, credit: Lianna Nixon).

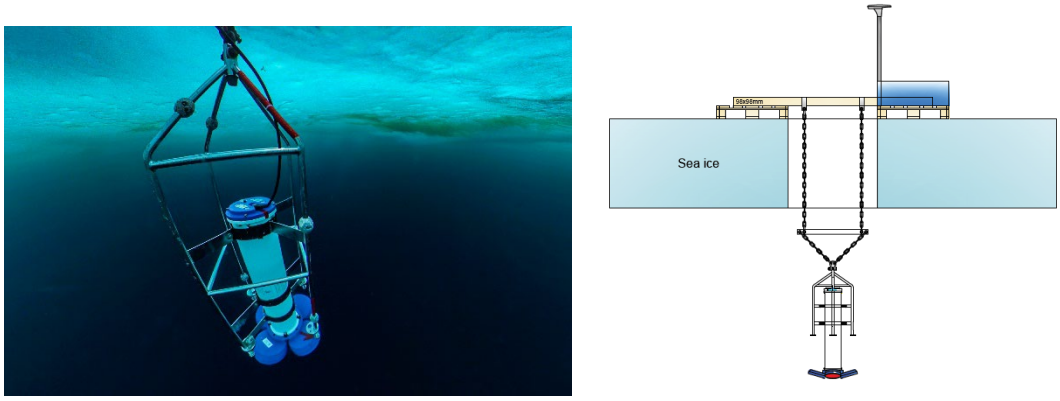

Fig. 5.3: Underwater photo of the deployed ADCP (left, credit: Lianna Nixon) and a schematic drawing of the ADCP setup (right, credit: UiB).

300 kHz ADCP [KS]

From June 29, the 300kHz ADCP – configured with the deployment file used during Leg 3, see Appendix - was deployed in the MSS hydrohole, using a T-frame and measured continuously, with an exception for weekly data downloads (swap of memory cards). On 27 July, the memory cards of the 300kHz ADCP were swapped, but the instrument did not communicate after the swap and was brought back to the ship, where it restarted again and was redeployed the next day. After reading out the data, it turned out that the instrument had stopped recording on 18 July at 18:39 UTC, for unknown reasons. In the afternoon of 29 July, the 300kHz ADCP was recovered together with all other installations on the floe.

Vessel mounted current profiler of RV Polarstern [ST]

Polarstern is equipped with an Ocean Surveyor 150kHz (RD-Instruments) Acoustic Doppler Current Profiler (VM-ADCP) to monitor ocean currents. For protection against ice, the Ocean Surveyor is mounted behind a window, flooded with water, in the ship's hull. When steaming through ice, air accumulates inside the window over time, which negatively affects the data quality. During PS122/4 the air was regularly released by the laboratory electrician.

The data from the VMADCP was merged online with the corresponding navigation data (i.e., the vessel's GPS system) and stored on the hard disk using the program VMDAS. Pitch, roll and heading data are converted from NMEA. Current speed data were collected in beam coordinates to apply corrections during post processing.

Processing during the cruise was done using GEOMAR sadcp software (OSSI19). Postprocessing will be done at AWI using the same software, including all MOSAiC legs. Final data processing and quality control will be done at AWI after the MOSAiC field campaign.

Microstructure profiler (MSS091) [KS]

On 21 June, we started to set up a light version of Ocean City approximately 350m away from Polarstern, and drilled a hydrohole of around 70x50 cm size for the microstructure profiler, by making seven connected holes with the 10 inch auger. On 27 June, we measured the first five microstructure profiles in our microstructure hole ("Ocean City"). Since the adjacent melt ponds started to drain into the MSS hole (draining started between 22-25 June), the first 3-4 m of the water column are occupied by a fresh water lense near freezing point. This lense leads to ice formation and false bottoms at the lower end of the iceholes, therefore regular hole maintenance was necessary. Electronics and the profiler were carried back on board after each measurement event, but the winch, mounted on a pallet, and power cables remained outside in a pop-up tent (Figure 5.4).

Since then, near-daily MSS stations consisting of 4-5 profiles each were carried out. No profiling was possible on 12 July, as the ship had to reposition and we had no access to the floe, no full station (only test profiles) were made between 22-25 July due to sensor malfunction (see below).

On 10-11 July, a combined diurnal sampling program was carried out, where we performed 24 hours of microstructure profiling (65 profiles) at Ocean City, and CTD casts every 6 hours.

On 22 July, a 13-hour continuous profiling station (34 profiles) was performed, in coordination with team ATMOS measurements.

On 23 July, the pressure sensor of the MSS091 broke. It was replaced with the pressure sensor of the malfunctioning MSS075, but a test on 25 July showed that also the temperature sensor was not working properly. We replaced the temperature sensor with the one from the MSS075, and a second test profile on 25 July was performed, showing reasonable data on all channels. Post-cruise calibration from the manufacturer is needed, and in addition we performed a calibration cast with the fishing rod CTD (#1459), between two MSS profiles on 26 July, and furthermore a calibration cast with the fishing rod CTD attached to the MSS with sensors at level on 29 July.

Fig. 5.4: Ocean City with tent and surrounding meltponds draining into the MSS hole (left, credit: Lianna Nixon) and MSS setup (right, credit: Lisa Grosfeld).

UiB VMP250 Upriser [MM]

During transit from Longyearbyen, the firmware for the uprising VMP250 from UiB was upgraded to ODAS5-IR v4.0.0, after communication with PI Ilker Fer who noticed spikes in the data during Leg 3. The VMP250 was tested for the first time on 2 July, and then deployed as often as possible in either the Ocean City hole, the ROV hole, or in leads. The deployment procedure is fully and detailed described in the Cruise Report Leg 2. In total 95 profiles were performed with the VMP250 during Leg 4, spread over 11 stations. The firmware upgrade appeared successful and no unusual spikes were detected in the data. During Leg 3, the LED light was disconnected under the suspicion that it was causing the spikes. This appeared not to be the problem, but the light was not reconnected during Leg 4. Overall, deployment with the VMP250 was relatively successful, considering that, on average, only 50% of profiles are good and without entanglement, even in open water conditions. Under ice deployment of the VMP205 was challenging, especially as it usually comes up quite far away from the hydrohole even with low drift speed. Our experience was that longer waiting time resulted in higher chance of entanglement, especially since we experienced quite large shear in the current speed between the surface layer and intermediate water masses. The shape of the releaser was the largest challenge, and we recommend for future deployments a releaser with rounded edges. During previous legs the linepuller sent by UiB was broken, but the ship's electrician connected a plug to the spare linepuller, which we connected to a large 12V battery. For deployment in leads, the linepuller was not used and the releaser was pulled up manually. The whole VMP250 setup was transported manually in 3 pulkas, or two pulkas when deployed in leads. A recovery weight was used to bring down the instrument in order to avoid dragging it under the ice when pulling it back to the hole. The 4 kg weight which was provided was not sufficient, 8-12 kg was needed to bring it down enough to avoid it getting stuck behind ridges and rafted ice. At multiple occasions, the instrument was stuck and this unfortunately resulted in dents and scratches on the buoyancy tubing. During melt season the underside of the ice was soft and porous, resulting in the protective caps penetrated the ice, and hence also the sensor came in touch with the ice base and broke. Sometimes also edges of floating ice pieces in the leads damages the sensors (Figure 5.6). The protective casing was not good enough to protect the fragile sensors and it was impossible to avoid ice touching the sensors in these challenging conditions. During two occasions 1-2 sticks of the protective casing broke. Table 1 in the Appendix shows the different changes made to the instrument and the sensors, and Table 2 gives an overview over the different deployments as logged in D-SHIP.

During Leg 4, we experienced melt season, which resulted in a thick freshwater lens under the ice and in the leads. The freshwater lens extended down to 2 m under the ice during the peak of melt season to approximately 30 cm just before the floe broke. Salinity in the freshwater lens was <10 and the gradient layer to more saline water >30 was only a few centimeters thick. A crosscutting team was established to investigate this freshwater lens and how it evolved in the leads surrounding our floe. Team Ocean contributed with VMP profiles and fishing rod CTD cast during these lead sampling days (see Section 8.4 about lead sampling). The main research question addressed for Team Ocean was: "*What is the rate of turbulent mixing in open water leads, and how is this impacted by the presence or lack of a freshwater lens?"*

In total 6 lead stations were performed with the VMP250. The lead sampling chapter contains more detailed information about the lead conditions. Video and photo documentation is available for lead sampling locations.

Fig. 5.5: VMP250 Upriser setup in lead (left, credit: Delphin Ruché) and in the Ocean City hole (right, credit: Lianna Nixon)

Fig. 5.6: VMP250 Upriser being deployed in lead (left, credit: Lianna Nixon) and illustrating how easily sensors can come in touch with floating ice (right, credit: Lianna Nixon)

Polarstern CTD rosette [ST]

During PS122/4 CTD-operations were carried out from *Polarstern* only, as the ice conditions did not allow for heavy installations on the ice.

After arriving at the parking position at the floe, we had to actively push the ship against the floe using the engine for the first 2-3 days to keep our position. The following days, the ice pressure was enough to keep us stable. After three stable days, on the 24 June, we started to work on a hydrohole next to the ship for CTD deployments. We managed to cut a 2.2 x 3.5m hole to about 1m depth. At that depth, the water level prevented chainsaw operations, as water was draining out of the ice. The hole was not yet connected to the ocean. When drilling through, we found that there was still more than 2m of ice and several big lose blocks of ice below the hole. In order to further open the hole by melting the ice, we deployed a submersible pump and a fire hose with seawater into the hole. Only a few hours later, ice movement and a crack through the hole forced us to retrieve the pump and hose (see Figure 5.7).

The next morning, the ice was again under pressure (presumably due to tidal dynamics), and the hole was back in place, but considerably deformed. We discussed several options (pushing actively against or away from the flow, operate the CTD from the A-frame, making another hole, etc.). We decided to observe the situation and use the pump and fire hose with seawater to further melt through the ice. In the night, the ice movement destroyed the hole.

In the morning of 27 June, another piece of ice had broken off and the ship maneuvered to push the ice blocks in the space between the ship and the floe out, creating a “CTD bay”

(see Figure 5.7). Now, the ship could press against the ice and keep a stable position, so it was possible to have a gangway, cables and a CTD at the same time.

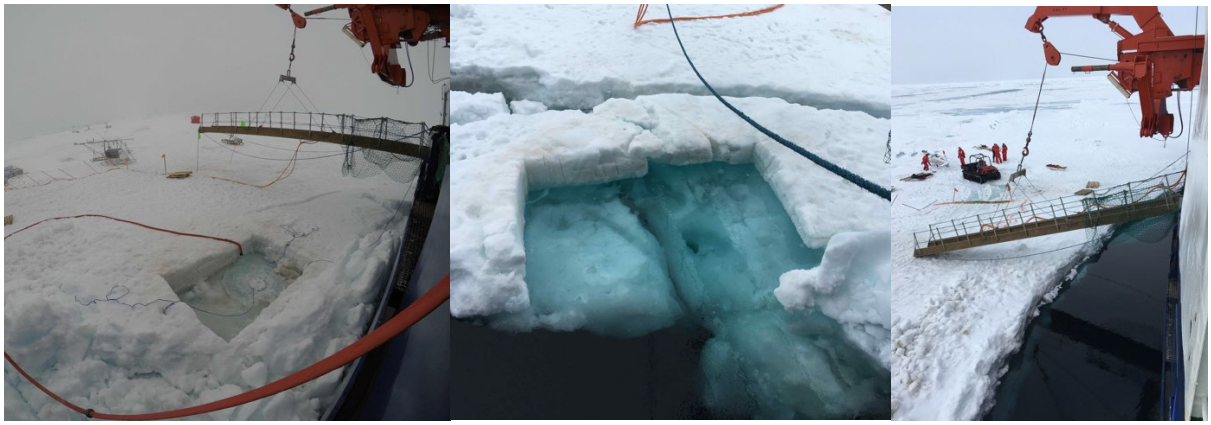

***Fig. 5.7**: Left: The hole after the first day with pump and seawater hose deployed. Middle: Ice hole a day later. Right: "CTD bay" after Polarstern pushed out the broken floes.*

The Polarstern CTD/Rosette was operated using the same setup as during the previous legs, with the standard SeaBird SBE911plus setup, equipped with double sensors for temperature, conductivity, and oxygen, and sensors for pressure, substance fluorescence (Chl. *a* and CDOM), photosynthetically active radiation (PAR), beam transmission, and nitrate. In addition, a rhodamine sensor and 24 12-liter OTE bottles for water sampling were attached. An altimeter was mounted to monitor the distance to the seafloor. Serial numbers as well as sensor web IDs are given in Table 5.

Additionally, a stand-alone, internally recording, battery-powered Underwater Vision Profiler (UVP, see Chapter 6) was attached. For detection of the *Polarstern's* wastewater (technical clean water), 7 tablets of Rhodamine dissolved in 20l of water were added to the wastewater during the release, using a flow controlled pump. This was carried out and documented by the *Polarstern* engine-crew.

Due to low readings and spikes in the fluorescence Chl. *a* signal during cast PS122-4_44-184 the fluorometer was changed (sn1853/sw4125 replaced by sn1670/sw5905). As this did not solve the issue, we switched back (sn1670/sw5905 replaced by 1853/4125) and replaced the cable instead, which solved the issue.

The fluorescence CDOM signal was very spiky from cast PS122-4_44-202 onwards, but no spare sensor or cable was available.

From cast PS122-4_45-3 and onwards we operated a sensor for surface photosynthetically active radiation (sPAR, sn20349/sw5921), installed at the helicopter deck, recording the radiation during CTD casts. Additionally, we had a second sPAR sensor right next to the first one, recording continuously (sn20460/sw). This sPAR sensor was operated with a separate data logger, build by the laboratory electrician Winfried Markert. Details are described in a separate report.

We additionally operated a high precision thermometer (SBE35, sn77/sw6345) mounted to the rosette. The response time of this thermometer is longer compared to the normal temperature sensors on the CTD, but the SBE35 has no pressure dependence. It measures only during times when a bottle is fired. The extra temperature data will be used to correct possible pressure effect of the standard SBE3plus temperature sensors.

The water budget for the ship-based water samplings was coordinated amongst teams ECO, BGC and Ocean. Team OCEAN required water samples for salinity calibrations, as well as water samples for density, oxygen, CFC/SF6, Helium/Neon and Tritium.

Besides the regular daily shallow casts and the weekly deep casts, we started a 27-hour yoyo-CTD-cycle on 3 July 10:00 UTC (PS122_4_45-72 - PS122_4_45-106).

During the coordinated diurnal sampling on June 10/11, we performed three CTD-casts including water sampling (PS122_4_46_83, PS122_4_46_87, PS122_4_46_91).

In total, 64 CTD casts were carried out from *Polarstern* during leg 4. Raw CTD data was processed following standard AWI procedures (based on the SBE Data Processing software and automatized by using Manage CTD). Data was copied to the MCS and the public server (//public/scientists/_CTD/). Final data processing and quality control will be done at AWI after the MOSAiC field campaign.

T-Pop deployment [KS, MM]

At the start of Leg 4, five T-Pops were available, which all were deployed (see Table 2), in close coordination with the PI Celine Heuze from the University of Gothenburg. Deployment happened always after a deep CTD cast.

Laboratory work

Salinometer measurements [ST]: For sensor calibration, salinity samples were taken from all deep CTD casts. At least one depth horizon was sampled, using a double sample from cast PS122_4_44_183 onwards. In total we took 101 samples. Samples were measured in the laboratory according to the procedures described in Howto_Salinometer.pdf using the salinometer salinometer_OPS_006 (sw7291).

Event relations where created and the data was stored in the MCS: /Platforms/vessel/Polarstern/salinometer_OPS_006. The data will be used in post processing of the CTD data.

Sampling for CFC/SF6, Helium/Neon, and Tritium [ST]: During PS122/4, we collected samples for CFC/SF6, Helium/Neon and Tritium from the *Polarstern* CTD rosette. In total we collected 125 CFC/SF6 samples, 70 Helium/Neon samples and 30 Tritium samples. We did not take any snow samples as there was no fresh snow falling. Following the sampling strategy, we sampled once a week, with two additional deep samplings to compensate for the gap in deep samples introduced during Leg 3 (no deep casts possible during leg 3). The sampling strategy was discussed and confirmed with Céline Heuzé (University of Gothenburg) and Maren Walter (University of Bremen). Replicate samples for CFC/SF6 was taken at the bottom, at the temperature maximum and at 10 m depth. Replicates for Helium/Neon where taken at 50 m. Tritium samples were taken every second week.

For flame sealing the same setup was used as during Leg 3. The filter was cleaned every other week by using a flow of nitrogen, heating for at least 2 hours and cool down after. Before sampling on the 16 June, the filter was blocked. As we could not allocate spare tubing, we flame sealed using Nitrogen directly from the bottle without the filter. This was communicated with Oliver Huhn (University of Bremen) and Céline Heuzé (University of Gothenburg) before sampling. After further communication, we decided to swap the tubing which was previously connecting the Nitrogen bottle and the filter, to connect the filter and the glass ampule. The part between Nitrogen bottle and filter was replaced using a larger diameter tubing provided by the *Polarstern* laboratory electrician. With this new setup the flow rate was harder to control, but flame sealing worked fine.

The samples will be sent to and analyzed by the Oceanography Department of the University of Bremen.

Dissolved oxygen [IS]: During PS122/4, at 12 CTD Stations a total of 85 oxygen samples for Winkler Titration were taken. The collection of seawater samples for the oxygen analysis from the Niskin bottles were done quickly after the CTD reached the deck. All samples were processed as described in the SOP „Determination of dissolved oxygen in seawater by Winkler Titration using Metrohm Titrino plus 848“. The sample bottles were stored in the chemical Lab and the analysis typically took place the next day, following the above mentioned SOP. The Mean Difference between Winkler and SBEOX1 were 26,79 µmol*kg^{-1}, between Winkler and SBEOX2 -1,276 µmol*kg^{-1} (see Table 5).

Instrument recoveries from previous legs [MM]

On 30 June, a scouting mission by kayak was organized to the old Fort Ridge site to check the status of the HAVOC instruments (CTD-Chain, Signature 1000 ADCP and SIMBA) and download data from the ADCP. The Fort Ridge site was found intact but had changed a lot since the pictures from Leg 3. The ADCP surface unit was found intact, but no data connection could be established with the instrument. The SIMBA was not found. After communication with the HAVOC PIs it was decided to recover the instruments, and a recovery mission to the old Fort Ridge site was carried out on 8 July to retrieve all instruments. A catamaran was built on two kayaks to shuttle gear such as chainsaws and drills to the site (Figure 5.7 and 5.8). We used the large auger to drill out the Signature 1000 ADCP pole, and found out that the lower part of the metal pole including the ADCP had been ripped straight off. The instrument was likely still there but moved sideways in between ice blocks. Using underwater cameras, we found multiple blocks of rafted ice under the site, up to 15m thick. Also the CTD chain was caught by the rafted ice, but we attempted recovery of the cable by making a large hole with the chainsaw and auger. We managed to free the chain, but also here, the kevlar and instruments had been ripped off.

Fig. 5.8: Fort Ridge during first visit on 30 June (left, credit: Morven Muilwijk) and recovery team traversing closed leads (right, credit: Saga Svavarsdottir)

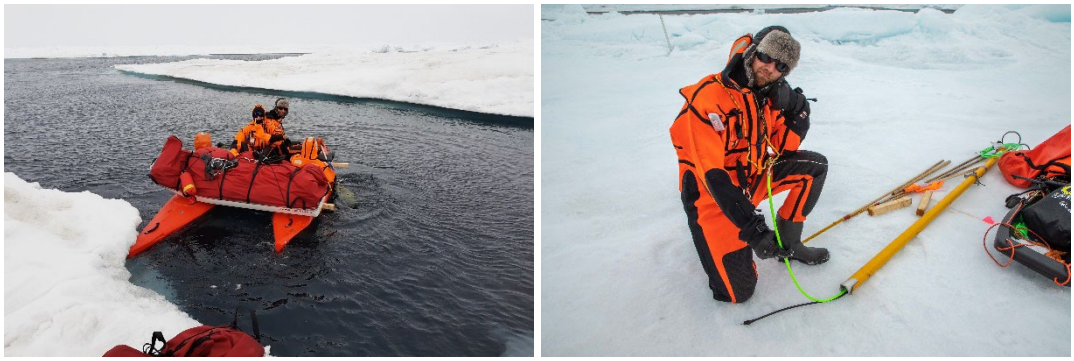

Fig. 5.9: Kayak catamaran used to transport pulkas across open leads (left, credit: Saga Svavarsdottir) and the broken ADCP pole (right, credit: Morven Muilwijk).

On 14 July, the Aural whale recorder (O. Böbel) and the CTD chain with three SBE microcats (B. Rabe) were recovered from the old Second Year Ice site. The Second Year Ice Site was during most part of Leg 4 located more than 1-2 nm away from Polarstern, but one day it drifted alongside the port side and we used this opportunity to go to the site by kayak. Data from the CTD chain were read out and put into the MCS, and the Aural was packed for shipment back to AWI Bremerhaven.

Fig. 5.10: Underwater picture of the recovery process of the Aural which was hooked through an angled auger hole (left, credit: Morven Muilwijk) and various surface installations at the old Second Year Ice (dark) site (right, credit: Antonia Immerz).

UiB Cluster [MM]

The UiB Cluster, located at the old CO was left by Leg 3 as a standalone system with an additional battery pack consisting of 4 large 12V batteries, which would provide power to the signature 1000 ADCPs for approximately two weeks. The old CO was at this point partly broken off, but at the time of arrival of Leg 4 it was a small floe, approximately 700m in diameter located about 1 nm away from the Leg 4 main floe. During Leg 4 the old CO floe was only accessible by helicopter or kayak. Shortly after arriving at the floe, on 18 June, we visited the UiB Cluster by helicopter for reading out data from the moored Signature 1000 ADCPs and changing batteries (6 in total). Data was successfully downloaded from the ADCPs, but due to a short flight window, time did not allow data download from the SAMI CO_2 sensors (Figure 5.11). Due to the lack of flying conditions in the weeks after we were not able to reach the Cluster to replace the batteries once more. After discussing with PI Ilker Fer, it was decided to keep the Cluster in the water for as long as possible since the SAMIs have internal batteries and will continue to measure. On 21 July it was clear that we were reaching the ice edge fast and that the surrounding ice was becoming more mobile. It was therefore decided that the Cluster was to be recovered at the first opportunity. On 22 July, a team of three people was deployed at the Cluster by helicopter to start the recovery

procedure. The Cluster was at this point partly in a melt pond, but not melted out. Ice thickness was approximately 90cm. An icehole was made and the surface units, including battery packs and buoyancy pallets were recovered with three helicopter flights. Extra buoyancy was attached to the Cluster mooring as well. The mission had to be aborted due to a polar bear encounter and the team was evacuated from the floe. On 24 July, the team revisited the old CO and started recovery off the mooring using a tripod and a manual winch system. The Cluster was pulled up 25m with help from Yale grips, and one out of three instrument clusters was successfully recovered. The recovery method was slow and difficult, but worked. Again, the mission had to be aborted due to a polar bear encounter, and the team was not able to return that day due to the time constraint. Between 25-30 July the team was on constant helicopter standby to return to the old CO, but fog and bad weather made this impossible. Meanwhile, the surrounding ice started to move a lot, and our floe rotated twice 360 degrees relative to the old CO. On 27 July, distance increased from 0.6 to 2 nm, and on 28 July to 8 nm. On 19 July the distance to the old CO increased to 16 nm. The main Leg 4 research camp was recovered on 30 July and the main Leg 4 floe broke up on 31 July. After all installations were recovered the *Polarstern* sailed to start recovery of instruments in the Distributed Network, including the old CO. In the afternoon of 31 July, the remaining pieces of the old CO floe were found, and after searching along a search grid the Cluster was found floating on a small ice floe, a few meters across (Figure 5.11). The remaining part of the Cluster mooring was successfully recovered by the *Polarstern* crane in the evening of 31 July. Data was successfully downloaded from all ADCPs. Data download was attempted with the SAMI CO_2 sensors, both directly to the instruments and via the cluster communication units without success due to software problems on both UiB laptops. The SAMI Client software was previously already slow and requested updates, but would at this point not work at all. It took one hour to start the program on both laptops and it crashed immediately when attempting to connect to the instrument. It was decided that the instruments were to be shipped back home to read out data in the lab. During the first night in the lab the deepest SAMI sensor popped open, possibly due to the pressure or temperature change. It appears that one of the small AA batteries exploded. It is unclear if the sensor or data storage unit has taken damage from this, and we were not able to check the status of the instrument due to the software problems. The instrument was packed to be investigated further in the lab at home. Three SBE microcats were recovered from the UiB Cluster. During previous legs it was reported that the microcats had battery issues and that it was not possible to download data from them anymore. It was our impression that the microcats technically should have battery for the whole period and would have continued to measure until the end. In the lab we attempted to connect to the instruments without luck. Communication was attempted with multiple laptops and both Seaterm and SeatermV2. Two microcats could not establish connection at all, and one could establish communication but gave an error message and contained no data (“unexpected mode, not logging”). We replaced all batteries, but this did not solve the problem. All microcats were packed and shipped back to Bergen for further investigation.

Fig. 5.11: UiB Cluster site on 18 June during battery swap (left, credit: Morven Muilwijk) and on 14 July during seismic station recovery (right, credit: Åshild Rye)

Fig. 5.1: Remainder of cluster mooring found by RV *Polarstern* on 31 July (left, credit: Lianna Nixon) and recovery by crane (right, credit: Lianna Nixon)

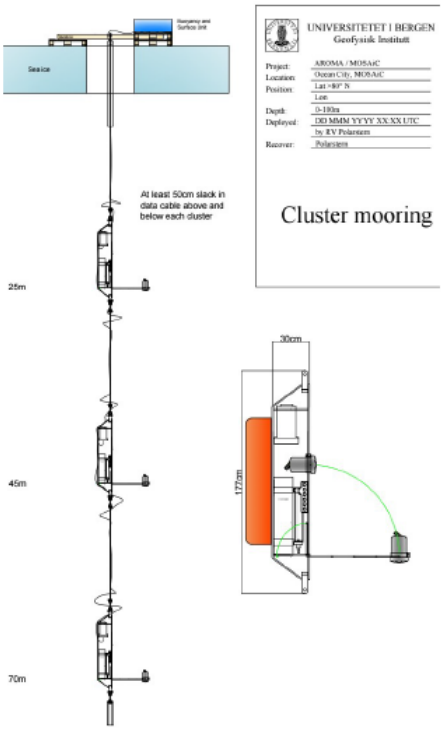

Fig. 5.2: Schematic drawing of UiB Cluster mooring, credit: UiB.

Preliminary (expected) results

Fresh water lens evolution

Upon arrival on the MOSAiC floe, a thin layer of fresh water with salinities as low as 1 and temperatures around 0°C was consistently present under the ice. Using the microstructure profiler at the Ocean City hole, we were able to monitor the evolution of this lens with a daily resolution, and happened to observe the onset of its destruction during the 24 hour cycle. Due to the length of the microstructure profiler, it is not possible to measure temperature and salinity in the upper ~1.50m of the water column, but for approximately the first half of the measurements on the floe, the ice thickness exceeded this value, hence the profiles covered the immediate under-ice layer.

In each profile, the interface between the fresh and salt water layer was determined based on the maximum Brunt-Vaisälä frequency, and temperature and salinity were averaged in the layer above the interface, to determine temperature and salinity in the fresh water layer. Results for the daily measurements are displayed in Fig. 5.14, results from the diurnal cycle with a temporal resolution of 20 minutes are displayed in Fig. 5.15. The time frame of the diurnal cycle is indicated in red in Fig. 5.14.

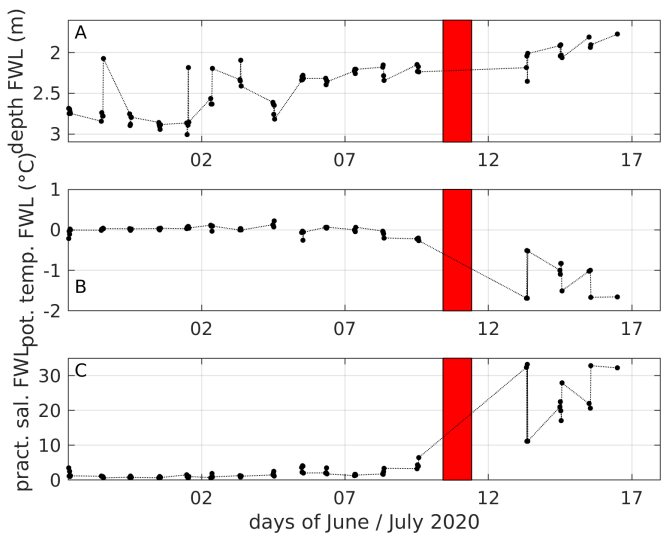

Fig. 5.14: Temporal evolution of the freshwater layer. (A) Depth of interface, (B) average temperature and (C) average salinity above the interface.

The freshwater layer had an initial vertical extent of 2.7m, deepening to 3m between 28 June and 1 July, relative to sea level. After 2 June, the layer shoaled to a depth of 2.2m. Over the whole time period, temperatures around 0°C and salinities between 1 and 4 prevailed in this layer and remained approximately constant. At 13 July, no freshwater layer could be detected with the microstructure profiler anymore. The onset of the dilution of the freshwater layer was observed in a 24-hour continuous sampling event, displayed in Fig. 5.15.

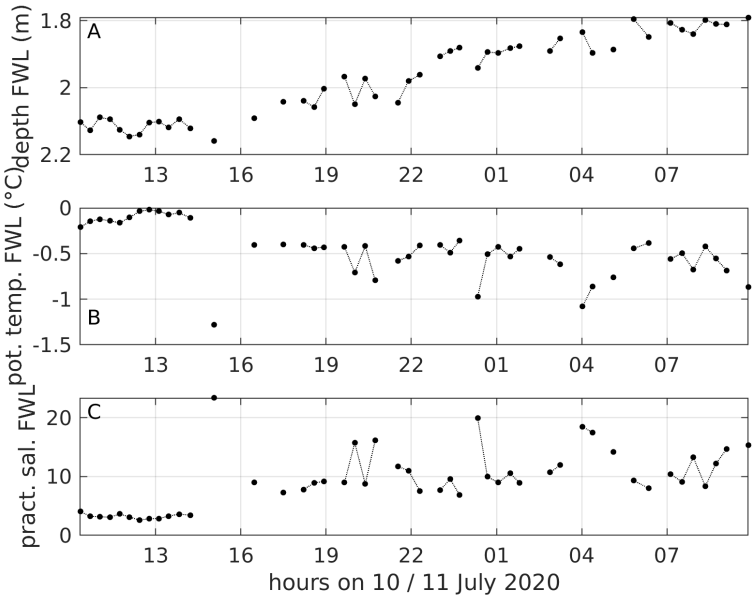

Fig. 5.15: Temporal evolution of the freshwater layer during the diurnal sampling event.

Low salinities around 5 and temperatures slightly below 0°C prevailed in the 2.1m deep freshwater layer during the first 5 hours. After 6 hours, the layer was nearly linearly getting shallower and diluted with seawater. Salinities rose to above 10 and temperatures decreased accordingly. In the next microstructure measurements 24 hours later, no freshwater layer was detectable.

The near surface turbulent dissipation rate, displayed in Fig. 5.16, increased over the course of the 24 hour measurements, and the turbulent near surface layer deepened from around 5m to 20m. A patch of enhanced turbulent dissipation was observed at the lower bound of the halocline at around 25m at 19:00 UTC that lasted for about 6 hours, and weakened afterwards. The upper bound of the halocline shoaled and the interface became less sharp when the turbulent near surface layer reached down to the depth of the halocline.

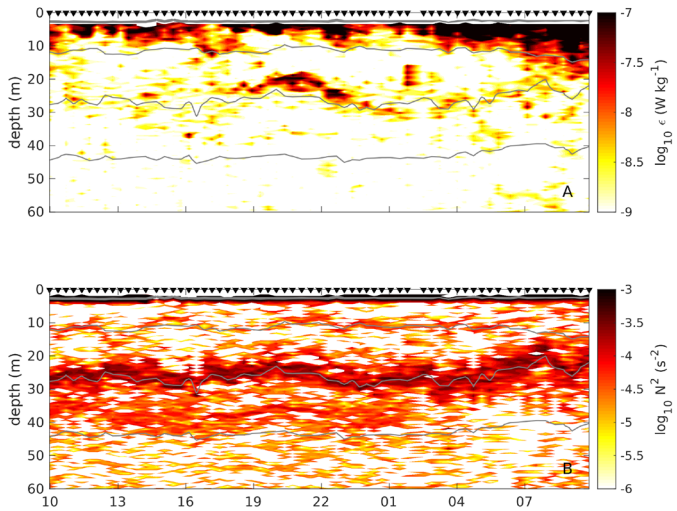

Fig. 5.16: Turbulent dissipation and buoyancy frequency in the upper 60m during the diurnal sampling. Black lines indicate isopycnals.

Data management

All data are handled, documented, archived and published following the MOSAiC data policy (see APPENDIX). Data from both Sea&Sun M48 CTDs, the MSS, VMP250 upriser, 75kHz ADCP and compass, 300 kHz ADCP, the VMADCP, the *Polarstern* CTD incl. the SUNA (note: all SUNA data files are located in the folder of the first CTD cast with the respective SUNA sensor), data from the recovered CTD chain from the old SYI floe and all available data from the UiB cluster are on the MCS, in the folders corresponding to their Dship log entries. The Aural whale recorder was sent home without downloading data, as requested by the PI O. Böbel. All T-Pop deployments were logged in Dship. Data will be stored at the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science www.pangaea.de.) DOIs will be communicated to PANGAEA for later access via the future MOSAiC Data Portal.

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Appendix

Tab. 1: Fishing Rod CTD casts

Lon / Lat	Time (UTC)	Station number in DSHIP - Comment
82°10.624'N 07°36.077'E	12-06-2020 08:32	PS122/4_44-43 CTD_48M_1459 - Stuck in the ice on the way in / deployed from aft of Polarstern / above Yermak Plateau (760m depth)
81°28,946' N 02°08,871' E	10-07-2020 19:31	PS122/4_46-180 CTD_48M_1459 – at ECO LODGE during diurnal sampling (by S. Tippenhauer)
81° 26,858' N 01° 36,129' E	11-07-2020 10:46	PS122/4_46-186 CTD_48M_1459 - at ECO LODGE during diurnal sampling (by S. Tippenhauer)
81°28.992'N 00°49.260'E	14-06-2020 13:23	PS122/4_47-73 CTD_48M_1459 - Calibration measurement at L2 (by M. Shupe)
80° 45,120' N 00° 30,532' W	20-07-2020 12:20	PS122/4_48-101 CTD_48M_1459 - In lead, with upriser measurements (M. Muijlwijk, I. Schuffenhauer)
80° 44,812' N 00° 31,578' W	20-07-2020 13:30	PS122/4_48-102 CTD_48M_1459 - In lead, with upriser measurements (M. Muijlwijk, I. Schuffenhauer)
80° 35,695' N 00° 36,819' W	21-07-2020 14:17	PS122/4_47-73 CTD_48M_1459 - In lead, with upriser measurements (M. Muilwijk, K. Schulz)
80° 23,420' N 00° 33,493' W	23-07-2020 05:55	PS122/4_48-106 CTD_48M_1459 - calibration cast, mounted on Polarstern CTD (S. Tippenhauer)

79° 46,917' N 01° 47,949' W	26-07-2020 12:50	PS122/4_48-197 CTD_48M_1459 – cast at MSS hole to compare data with new sensors on MSS (K. Schulz / S. Tippenhauer)
79° 46,002' N 01° 52,930' W	26-07-2020 14:40	PS122/4_48-198 CTD_48M_1459 - cast at MSS hole to compare data with new sensors on MSS091 (K. Schulz / S. Tippenhauer)
79° 24,457' N 02° 44,333' W	28-07-2020 06:38	PS122/4_49-80 CTD_48M_1459 – calibration cast, attached to CTD (S.Tippenhauer)
79° 24,457' N 02° 44,333' W	28-07-2020 06:38	PS122/4_49-79 CTD_48M_1495 – calibration cast, attached to CTD (S.Tippenhauer)
79° 10,966' N 02° 35,854' W	29-07-2020 13:02	PS122/4_49-81 CTD_48M_1459 – calibration cast, attached to MSS091 (I. Schuffenhauer, K. Schulz)

Tab. 2: T-Pop deployments

Lon / Lat	Time (UTC)	Station number in Dship - comment
82° 13,080' N 08° 18,299' E	2020-06-16 08:31	PS122/4_43-42 Tpop_70 – programmed by M. Muilwijk, deployed by M. Muilwijk
81° 13,551' N 00° 17,042' E	2020-07-16 12:38	PS122/4_43-107 Tpop_76 – programmed by M. Muilwijk, deployed by K. Schulz
80° 21,055' N 00° 37,233' W	2020-07-23 11:25	PS122/4_43-113 Tpop_75 – programmed by M. Muilwijk, deployed by M.Muilwijk
79° 11,848' N 02° 36,974' W	2020-07-29 09:12	PS122/4_43-125 Tpop_72 – programmed by M. Muilwijk, deployed by K. Schulz
78° 33,688' N 01° 43,084' W	2020-08-05 14:05	PS122/4_43-154 Tpop_62 – programmed by M. Muilwijk, deployed by M. Muilwijk

Tab. 3: Overview over sensor and instrument changes for the VMP250 during PS122/4

Date	VMP250 Instrument action
10.06.2020	Firmware Upgrade to ODAS5-IR v4.0.0
13.07.2020	Replaced sensor C165 with C177. Temperature sensor T1127 gave strange values in lab. Replaced by T996. Communication with Ilker revealed that SH2 was broken. Replaced M555 with M952. Updated SETUP.CFG with new serial numbers and calibration coefficients.
17.07.2020	Strange jump in mT sensor at profile 4. MC sensor broke again when stuck in iceberg. Unfortunately no replacement sensor available.
18.07.2020	Replaced sensor T996 With T626 and updated setup.cfg. Suspicious jump in T996. Replaced to be on safe side. Changed from 3 to 4 brushes to decrease speed (now 0.7m/s).
21.07.2020	Silicon tip of sh1 was broken. Replaced sh1(M1144) with dummy. Saving spare sensors for next leg. Some slight green corrosion on the outside of connector screw (Where probe is screwed into). No corrosion on the inside of the screw.
22.07.2020	Temperature sensor replaced with dummy before sampling. (Appears broken in DAT020).
24.07.2020	Replaced T-dummy with T704. Replaced sh1-dummy with M1142.

	Updated setup file. New additional sensors shipped onboard for leg 5.

Tab. 4: Overview over VMP250 stations during PS122/4.

Date	Operators	Profiles	Location	Comments/DShip entry
02.07.2020	Morven Muilwijk, Sandra Tippenhauer, Ingo Shuffenhauer	1 datafile (001), 5 profiles	ROV hole	Strong drift, 3 profils slightly entangled. PS122/4_45-91
06.07.2020	Morven Muilwijk, Ingo Schuffenhauer	2 datafiles (002, 003), 5 profiles	ROV hole	Low drift, two profiles entangled. PS122/4_46-62
07.07.2020	Morven Muilwijk, Sandra Tippenhauer	1 datafile (004), 5 profiles	MSS hole	Low drift, no entanglement. PS122/4_46-63
13.07.2020	Ingo Schuffenhauer, Kirstin Schulz	1 datafile (005), 3 profiles.	MSS hole	Large entanglement. First profile successful but micoconductivity sensor broke when profiler came up. Two more profiles done after this but ith lot's of entanglement. Protective casing broken under ice but fixed in ship's worksop later. PS122/4_47-58
15.07.2020	Morven Muilwijk, Sandra Tippenhauer	4 datafiles (008, 009, 010, 011), 26 profiles	ROV hole	Full day VMP sampling (09-17). PS122/4_47-59
17.07.2020	Morven Muilwijk	2 data files (012, 013), 8 profiles.	Lead	Two locations combined With ECO, BGC and ICE lead sampling team. Maddison Smith from ICE took cast away CTD profiles simultaneously. Additional samples from the freshwater layer and Interface between freshwater and saltwater were taken for gasses and ECO. 5 profiles at first location at the end of albedo-line (see map of leg4 floe). 3 profiles at second location half way between albedo line and Ali's Ridge. Strange jump in mT sensor at profile 4. MC sensor broke again when stuck in iceberg. Profiler did not come up in lead but under the ice. Very low drift

				speed. PS122/4_47-109
18.07.2020	Morven Muilwijk, Sandra Tippenhauer	3 datafiles (014, 015, 016). 10 profiles	Lead	One location near Ali's Ridge (see leg4 floe map). Large open lead (+150m), low drift, small ice blocks (~5m diameter) floating around. Relative fast surface drift. Profiler came up in open water in the lead. Changed from 3 to 4 brushes to decrease speed (now 0.7m/s). Used extra weights (12kg) to pull down profiler in lead for recovery in order not to get stuck in the ice. Got stuck during recovery in-between two floating ice blocks for one profile (nr.7). One protection cap (plastic) broke during the process. PS122/4_47-110
20.07.2020	Morven Muilwijk, Ingo Schuffenhauer	2 datafiles (017 and 018), 14 profiles.	Lead	Very successful. Low drift, no floating ice in lead. Approximately 100m open water. Profiler always came up in open water 5m away from floe edge. No dragging along ice or hitting icebergs. Location: close to Ali's Ridge (see leg4 floe map). PS122/4_48-8
21.07.2020	Morven Muilwijk, Kirstin Schulz	2 datafiles (019 and 020), 12 profiles.	Lead	Quite unsuccessful lead sampling. Extremely low drift. Profiler came up just 1 m away from ice edge but always very entangled. Profiler just spins around releaser and weight. 12 profiles all entangled. Some just with rope around releaser, others with back cable multiple times around profiler itself. No sensors damaged or broken in process. All very controlled but entangled profiles. Fishing rod CTD at same location. PS122/4_48-31
22.07.2020	Sandra Tippenhauer	1 datafile (021), 6 profiles	Lead	Cast away CTD at same location. Near Ali's Ridge (see leg 4 Floe map). Combined sampling with ECO+BGC. First 2 profiles good, third profile looped. 3 last profiles bad entanglement.

				Surface drift parallel to lead edge. Profiler came up in lead (~30m away). 2/3 open water in lead. Little icebergs. Only one working shear sensor. PS122/4_48-67
28.07.2020	Morven Muilwijk, Sandra Tippenhauer	1 datafile (022). 1 profile.	Lead	Lead sampling near Ali's Ridge. Did 1 profile only (good profile) but were called back to the ship due to increasing fog and poor visibility. PS122/4_49-114

Tab. 5: Results of the oxygen titration.

O2	Flask vol.	t°C	Flask vol.	Thiosulfat	Device operation	CTD Ni	Sample	Depth	Salinity	Pot.temp.	Seawater den	Oxygen	Oxygen
Flask nr.	at/20° C	analysis	at in situ tem	ml		nr.		[db]	PSU	°C	gr*cm-3	ml*l-1	µmol*kg-1
1	116,61	21	116,5864966	0,762	PS122/4_44-67	1	1	750	34,9078	-0,1556	1,028040077	7,195086293	312,5681196
2	115,26	21	115,2367687	0,7513	PS122/4_44-67	1	2	750	34,9078	-0,1556	1,028040077	7,178389739	311,8427898
3	117,97	21	117,947477	0,746	PS122/4_44-67	3	3	500	34,9164	0,9079	1,027984486	6,961003877	302,4154912
4	116,72	21	116,6977157	0,7137	PS122/4_44-67	3	4	500	34,9164	0,9079	1,027984486	6,731500743	292,444903
5	117,41	21	117,3844827	0,8055	PS122/4_44-67	20	5	10	33,9835	-1,7335	1,027352766	7,554109657	328,3843178
6	117,94	21	117,9143675	0,8011	PS122/4_44-67	20	6	10	33,9835	-1,7335	1,027352766	7,478417973	325,0939284
1	116,61	21	116,5861531	0,7514	PS122/4_44-184	1	7	898	34,9152	-0,4501	1,028060675	7,094802178	308,2054132
2	115,26	21	115,2374668	0,732	PS122/4_44-184	1	8	898	34,9152	0,4501	1,028012293	6,993538251	303,8207037
3	117,97	21	117,9472113	0,7395	PS122/4_44-184	4	9	500	34,9119	0,6826	1,02799537	6,900233654	299,7722014
4	116,72	21	116,6974527	0,7362	PS122/4_44-184	4	10	500	34,9119	0,6826	1,02799537	6,94422257	301,683246
5	117,41	21	117,3845176	0,8156	PS122/4_44-184	20	11	10	33,8579	-1,7038	1,027249875	7,649020359	332,5434808
6	117,94	21	117,9144025	0,8009	PS122/4_44-184	20	12	10	33,8579	-1,7038	1,027249875	7,47654484	325,0450553
7	116,96	21	116,9346165	0,8295	PS122/4_44-202	24	13	10	33,8177	-1,7027	1,027217169	7,810095883	339,5570991
8	118,92	21	118,8941697	0,841	PS122/4_44-202	24	14	10	33,8177	-1,7207	1,027217641	7,785845047	338,5025977
9	118,29	21	118,2643066	0,8437	PS122/4_44-202	24	15	10	33,8177	-1,7207	1,027217641	7,853205727	341,4312156
177	116,43	21	116,4062209	0,7668	PS122/4_44-202	18	16	75	34,3622	-0,4235	1,027612145	7,251916829	315,1681373
178	115,58	21	115,5563945	0,7622	PS122/4_44-202	18	17	75	34,3622	-0,4235	1,027612145	7,26226467	315,6178542
245	118,62	21	118,5957736	0,7767	PS122/4_44-202	18	18	75	34,3622	-0,4235	1,027612145	7,207800081	313,2508244
10	116,11	21	116,0865601	0,713	PS122/4_44-202	1	19	800	34,9161	-0,1877	1,028048435	6,760908068	293,704211
19	117,58	21	117,5562633	0,7199	PS122/4_44-202	1	20	800	34,9161	-0,1877	1,028048435	6,739664579	292,7813613
20	116,22	21	116,1965379	0,7112	PS122/4_44-202	1	21	800	34,9161	-0,1877	1,028048435	6,737305774	292,6788911
13	116,54	21	116,5174955	0,7364	PS122/4_45-003	5	22	100	34,6044	0,6895	1,02774731	6,957028682	302,3125412
14	118,63	21	118,607092	0,7492	PS122/4_45-003	5	23	100	34,6044	0,6895	1,02774731	6,951383508	302,0672343
15	117,13	21	117,1049909	0,7907	PS122/4_45-003	10	24	50	34,146	-1,3516	1,02747352	7,433033981	323,0830685
16	115,47	21	115,4453453	0,781	PS122/4_45-003	10	25	50	34,146	-1,3516	1,02747352	7,449063155	323,77979
17	115,66	21	115,6348729	0,8007	PS122/4_45-003	19	26	30	34,0275	-1,725	1,027388312	7,624616855	331,4378651
18	115,57	21	115,5448924	0,7983	PS122/4_45-003	19	27	30	34,0275	-1,725	1,027388312	7,607740115	330,7042426
1	116,61	21	116,5864223	0,7216	PS122/4_45-31	1	28	780	34,9161	-0,2193	1,028050046	6,812931542	295,9637265
2	115,26	21	115,2366952	0,7123	PS122/4_45-31	1	29	780	34,9161	-0,2193	1,028050046	6,805046792	295,6212014
3	117,97	21	117,9473207	0,724	PS122/4_45-31	4	30	500	34,9111	0,7754	1,027988832	6,755420602	293,482842
4	116,72	21	116,6975609	0,7182	PS122/4_45-31	4	31	500	34,9111	0,7753	1,027988839	6,774173723	294,2975518
5	117,41	21	117,3845158	0,8357	PS122/4_45-31	20	32	10	33,7787	-1,7053	1,027185536	7,838510075	340,8029492
6	117,94	21	117,9144008	0,8377	PS122/4_45-31	20	33	10	33,7787	-1,7053	1,027185536	7,821394416	340,0587941
1	116,61	21	116,5857476	0,7301	PS122/4_46-60	1	34	1139	34,9174	-0,7979	1,028078188	6,893440812	299,4529699
2	115,26	21	115,2360283	0,728	PS122/4_46-60	1	35	1139	34,9174	-0,7979	1,028078188	6,955489744	302,1483926
3	117,97	21	117,9475554	0,7192	PS122/4_46-60	5	36	500	34,9041	0,9743	1,027970188	6,710499237	291,5365636
4	116,72	21	116,6977932	0,708	PS122/4_46-60	5	37	500	34,9041	0,9743	1,027970188	6,67769135	290,1112302
5	117,41	21	117,3844858	0,8713	PS122/4_46-60	21	38	10	33,7175	-1,7309	1,027136448	8,173202852	355,3717132
6	117,94	21	117,9143706	0,8606	PS122/4_46-60	21	39	10	33,7175	-1,7309	1,027136448	8,035704912	349,3932884
1	116,61	21	116,5856837	0,709	PS122/4_47-60	2	40	2520	34,9297	-0,8527	1,02809048	6,693691704	290,7723369
2	115,26	21	115,2359652	0,7081	PS122/4_47-60	2	41	2520	34,9297	-0,8527	1,02809048	6,764855479	293,863674
3	117,97	21	117,9476368	0,7308	PS122/4_47-60	8	42	500	34,8938	1,0433	1,027957269	6,819021377	296,2550134
4	116,72	21	116,6978737	0,7159	PS122/4_47-60	8	43	500	34,8938	1,0433	1,027957269	6,752402528	293,3607319
5	117,41	21	117,3845874	0,9147	PS122/4_47-60	21	44	10	32,4776	-1,6443	1,026126736	8,581217142	373,479361
6	117,94	21	117,9144727	0,9095	PS122/4_47-60	21	45	10	32,4776	-1,6443	1,026126736	8,493325534	369,6540643
1	116,61	21	116,5895586	0,721	PS122/4_47-108	5	46	250	34,9114	2,4703	1,027861752	6,807065084	295,7630498
2	115,26	21	115,2397089	0,7147	PS122/4_47-108	6	47	200	34,8795	2,3954	1,027842627	6,82785646	296,6719432
3	117,97	21	117,9461876	0,7494	PS122/4_47-108	7	48	150	34,4907	-0,1851	1,027704564	6,99312597	303,8937616
4	116,72	21	116,6946384	0,8149	PS122/4_47-108	8	49	100	34,1115	-1,7286	1,0274567	7,688932169	334,2113692
5	117,41	21	117,3844639	0,8091	PS122/4_47-108	9	50	90	34,0881	-1,7495	1,027438235	7,588435644	329,84906
6	117,94	21	117,9143542	0,8203	PS122/4_47-108	10	51	80	34,0626	-1,7448	1,027417377	7,658560541	332,9039605
7	116,96	21	116,9345363	0,8336	PS122/4_47-108	11	52	70	34,018	-1,7713	1,027381809	7,849378296	341,2102799
8	118,92	21	118,8941288	0,8551	PS122/4_47-108	12	53	60	33,9404	-1,7551	1,027318291	7,917312904	344,1846577
177	116,43	21	116,4047027	0,827	PS122/4_47-108	13	54	50	33,8012	-1,7275	1,027204404	7,823149703	340,1288627
10	116,11	21	116,0847672	0,82	PS122/4_47-108	14	55	40	33,5793	-1,7318	1,027024125	7,778528959	338,2482407
11	116,35	21	116,3247448	0,8167	PS122/4_47-108	15	56	30	33,3315	-1,7062	1,026822065	7,730888859	336,2427709
12	115,23	21	115,2050355	0,8407	PS122/4_47-108	16	57	20	32,5768	-1,6649	1,026207796	8,037333131	349,7803262
13	116,54	21	116,5147919	0,8833	PS122/4_47-108	17	58	15	32,3424	-1,6304	1,026016592	8,348948945	363,4093861
14	118,53	21	118,5044944	0,9208	PS122/4_47-108	21	59	10	32,121	-1,5183	1,025834237	8,555527017	372,4674247
15	117,13	21	117,1047786	0,9536	PS122/4_47-108	23	60	2	32,0979	-1,5328	1,025815817	8,968681402	390,4612358
47	117,69	21	117,6654457	0,7097	PS122/4_48_155	2	61	2724	34,9314	-0,8635	1,028092312	6,632713222	288,1229333
75	115,29	21	115,2659465	0,6965	PS122/4_48_155	2	62	2724	34,9314	-0,8635	1,028092312	6,647043352	288,7454295
83	115,5	21	115,4760091	0,7	PS122/4_48_155	5	63	2000	34,923	-0,7713	1,02808158	6,668133886	289,6646193
113	119,09	21	119,0654923	0,7314	PS122/4_48_155	6	64	1500	34,9195	-0,5791	1,028070185	6,754091409	293,4018774
109	119,1	21	119,0759445	0,7378	PS122/4_48_155	8	65	1000	34,907	-0,1977	1,028041592	6,812676423	295,9550775
153	115,19	21	115,1667343	0,7113	PS122/4_48_155	8	66	1000	34,907	-0,1977	1,028041592	6,794471087	295,1642045
178	115,58	21	115,5577014	0,6928	PS122/4_48_155	9	67	500	34,8667	0,7072	1,027957421	6,594687419	286,508696
16	115,47	21	115,4459369	0,6918	PS122/4_48-62	1	68	2400	34,9289	-0,8393	1,028089266	6,5964729	286,5495141
17	115,66	21	115,6358973	0,6903	PS122/4_48-62	1	69	2400	34,9289	-0,8393	1,028089266	6,571126714	285,4484806
18	115,57	21	115,545968	0,7041	PS122/4_48-62	3	70	500	34,9247	-0,7943	1,028083947	6,708171486	291,4031869
19	117,58	21	117,5555501	0,7067	PS122/4_48-62	3	71	500	34,9247	-0,7943	1,028083947	6,61591978	287,3957698
20	116,22	21	116,1949655	0,9205	PS122/4_48-62	20	72	10	31,9939	-1,5406	1,025731551	8,725707924	379,914331
245	118,62	21	118,5944485	0,9353	PS122/4_48-62	20	73	10	31,9939	-1,5406	1,025731551	8,683832306	378,0910809

Tab. 6: Sensor configurations of the Polarstern CTD/Rosette system. Sn = serial number, SW ID = Sensor Web ID.

PS122-4	Conf 1	Conf 2	Conf 3	Conf 4	Conf 5
	SN/SW ID	**SN/SW ID**	**SN/SW ID**	**SN/SW ID**	**SN/SW ID**
SBE9plus	321/3214	321/3214	321/3214	321/3214	321/3214
SBE32	55/5895	55/5895	55/5895	55/5895	55/5895
Temperature 0	1338/5842	1338/5842	1338/5842	1338/5842	1338/5842
Temperature 1	1374/5844	1374/5844	1374/5844	1374/5844	1374/5844
Conductivity 0	3173/5865	3173/5865	3173/5865	3173/5865	3173/5865
Conductivity 1	3590/5879	3590/5879	3590/5879	3590/5879	3590/5879
Oxygen 0	1834/5883	1834/5883	1834/5883	1834/5883	1834/5883
Oxygen 1	467/5880	467/5880	467/5880	467/5880	467/5880
Pump 0	2544/5887	2544/5887	2544/5887	2544/5887	2544/5887
Pump 1	4316/5888	4316/5888	4316/5888	4316/5888	4316/5888
Altimeter	47768/5900	47768/5900	47768/5900	47768/5900	47768/5900
Fluoro Chl *a*	1853/4125	1670/5905	1853/4125	1853/4125	1853/4125
Trans	1198/4126	1198/4126	1198/4126	1198/4126	1198/4126
PAR under water	70257/5920	70257/5920	70257/5920	70257/5920	70257/5920
PAR surface				20349/5921	20349/5921
Fluoro CDOM	4531/5911	4531/5911	4531/5911	4531/5911	4531/5911
Suna	732/6015	732/6015	732/6015	732/6015	1318/4998
Cyclops	216k00137/7118	216k00137/7118	216k00137/7118	216k00137/7118	216k00137/7118
Deck Unit	794/5918	794/5918	794/5918	794/5918	794/5918
SBE35	77/6345	77/6345	77/6345	77/6345	77/6345

Tab. 7: Deployment file used for the 300kHz ADCP in Ocean City

```
; configuration file for MOSAiC Ocean City ADCP300kHz
; deployed downward looking in the ice hole
; 01.03.2020   v.mohrholz
;

CR1
CF11101
EA0
EB0
ED20
ES35
EX00000
EZ1111101
RN OCS08
WA255
WB0
WC032
WD111100000
WF176
WN52
```

WP1 WS200 WM1 WV175 TE00:00:01.00 TP00:00.00 TF20/03/01 08:00:00 CK CS ;

Tab. 8: Deployment file used for the 300kHz ADCP in Ocean City

; Restore factory default settings in the ADCP cr1
; set the data collection baud rate to 38400 bps, ; no parity, one stop bit, 8 data bits ; NOTE: VmDas sends baud rate change command after all other commands in ; this file, so that it is not made permanent by a CK command. cb611
; Set for narrowband single-ping profile mode (NP), fifty (NN) 8 meter bins (NS), ; 6 meter blanking distance (NF) WP0 NN050 NP00001 NS0800 NF0600
; Disable single-ping bottom track (BP), (Fang: No need here, 4200-m ocean) BP000
; output velocity, correlation, echo intensity, percent good ND111100000
; ping as fST AS POSSIBLE TP000000
; Set to calculate speed-of-sound, no depth sensor, external synchro heading ; sensor, no pitch or roll being used, no salinity sensor, use internal transducer ; temperature sensor EZ1020001
; Output beam data (rotations are done in software) EX00000
; Set transducer misalignment (hundredths of degrees) EA00000
; Set transducer depth (decimeters)
ED00110
; Set Salinity (ppt). From Ocean City CTD, lower halocline starts at 34 from 40 - 180m ; to 35.5 at 120m and stays relatively constant (34.9) below 240m. ES34

;set external triggering and output trigger; no trigger CX0,0
; save this setup to non-volatile memory in the ADCP CK