8 OVERARCHING AND SUPPORTING ACTIVITIES

Grant-No. AWI_PS122_00

8.1 LOGISTIC & SAFETY

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Objectives

The main objective was the overall safe conduction of the expedition.

For MOSAiC a specific safety concept based on the AWI safety standards as well as project specific needs and experiences from previous drift expeditions had been developed by B. König and V. Mohaupt.

Work at sea

A safety briefing, including specific information about MOSAiC as well as general field safety and polar bear safety and awareness was mandatory for all participants before departure in Bremerhaven, to ensure a good level of general safety awareness and knowledge.

Due to Covid-19 restrictions and quarantine regulations practical parts such as self-rescue from sea ice and the use of emergency equipment was carried out during transit.

After arrival at the former Central Observatory ice floe, conditions of the floe needed to be assessed and remaining equipment needed to be located.

Feasibility of rules and regulations needed to be verified. If required, the safety concept was adapted to match conditions. Expedition participants were informed directly as well as via corrections to the MOSAiC handbook. The science team was a consulted body during this process.

Current check of work safety standards was carried out by V. Mohaupt. Necessary measures were taken if required and participants were briefed accordingly.

The logistic team in general was the controlling body for the predefined safety rules and standards during the expedition. The main tasks were carrying out bridge watch, stern watch and polar bear watches on the ice. Further duties were the management of infrastructure and the distribution and maintenance of safety equipment including rifles and flare guns for polar bear protection.

The logistic team was also responsible for vehicles and vehicle maintenance (snow scooter, ARGO). An introduction regarding safe use of snow scooters and basic technical knowledge was required for all participants.

Mandatory refresh courses for weapon handling were held on site for all potential polar bear guards among participating scientists. Proper weapon handling was checked throughout the expedition. Regular maintenance of weapons and weapon equipment was carried out.

The bridge watch was in charge of coordination and monitoring of the teams on the ice. In case of events (cracks, fog, bad weather, polar bears, breaks ups) the logistic bridge watch was managing and advising the teams and inform and consult the cruise leader if needed. All actions were carried out in cooperation with the nautical officer on watch.

In case of polar bear encounters members of the logistic team – in consultation with the Cruiseleader – took measures to scare the animal(s) away.

According to the developed emergency concept, a member of the logistic team, together with the officer on watch would be in charge of a potential medical evacuation. The emergency concept - mainly the evacuating resources – were adapted to the arctic summer conditions.

An exercise of a medical evacuation situation was carried out to assess the concept in terms of flaws and allow optimization in close contact with the ship's management.

Organisation and management of freight and cargo issues was undertaken in close cooperation with the ship's management by V. Mohaupt.

The logistic team assisted during the re-build-up of the central observatory as well as in the final evacuation after floe break up. The team also assisted in field trips and logistic operations (retrieval or moving of equipment) and took responsibility in maintenance of infrastructure (power lines, roads, shelters, ice holes, bridges).

Preliminary (expected) results

Not applicable

Data management

Not applicable

References

Not applicable

Special requirements on notations:

Not applicable

Images

Not applicable

8.2 DATA SUPPORT

Antonia Immerz[1], Thomas Schmidt[2]

Not on Board[1]: Janik Eilers, Peter Gerchow, Antonia Immerz, Sebastian Immoor, Roland Koppe, Jörg Matthes, Martin Petri, Stefan Pinkernell, Steven Rehmcke, Jens-Michael Schlüter, Ralf Spettnagel, Andreas Thiele.

[1]AWI

[2]FIELAX

Objectives

General accessibility of data requires a central data storage and a common meta data concept. All sensors and sampling devices used in scientific events during the MOSAiC expedition shall therefore be registered in SENSORWeb and all device operations performed during the expedition logged in the ships station book, the DSHIP ActionLog. A predefined structure on the MOSAiC central storage further ensures that data can be found in an organised manner, also after the expedition. In this way all subsequent sample analyses can then be referenced to the original sampling event. A full description of the data management concept in MOSAiC can be found in the MOSAiC Data Policy (see Appendix).

Work at sea

For general tasks, see Work at Sea, Leg1, Leg 2, Leg 3.

Network on the ice:

At the beginning of PS122/4 fibre optic cables were not deployed any more. Due to several breakups of the floe during leg PS122/3 the fibre optic cables to Ocean City and Met City got severely damaged. Therefore, the solution for the data transfer was the installation of radio links again as already used and well experienced up to the end of PS122/3. Because the MET-hut had been destroyed at the end of PS122/3, the former RS-Hut needed to be reconfigured and used as new MET-Hut. The new MET-Hut was established by helicopter sling load operation in a distance of about 400m perpendicular to the starboard side of the ship. Quite close to that location new Ocean-City and Balloon-Town were also built up in a distance of less than 100m besides MET-hut. That offered the big advantage to supply three sites by same radio link via MET-hut and Wifi. Since the power hubs are too heavy to be deployed on the weakening surface of the floe, the hubs cannot be used in summer any more. Therefore, the distribution of power at the sites needed to be reduced to "light" versions of a hub which simply consists of weatherproof boxes (wooden or aluminium) containing adapters/distributers to be connected to the main power cable. This approach was also chosen for new Remote Sensing area: It was installed only 100 m away from ship perpendicular on starboard side and quite in the same direction as the radio link to MET-hut. Due to the short distance to ship, a hut was not required at Remote Sensing. To install a radio link to Remote Sensing was simply done by putting all the devices necessary (Moxa-Switch, Wifi, Power-Supply DC 24V) into a weather proof box which was provided by the MET-Team. MET-City, Ocean-City and Balloon-Town shared the same receiver (Slave1). A separate receiver (Slave 2) was required for Remote Sensing. Both Slaves were connected via radio link to the same transmitter (Master 3) located in crow’s nest on starboard side of the ship. This solution supported a stable network connection during the entire period of PS122/4. Even though power cables needed to be disconnected several times (e.g. caused by ship's movements), the radio link re-connected automatically without any problems, each time power was back again. Because the floe did not break into separate parts, there also was no need to readjust the radio link as often as this was necessary during PS122/3. So in summary, it was straight forward to maintain radio link.

Assistance was provided to scientists when connecting their instruments to the network, both within the vessel and on the main sites.

Kepler Transfer:

As already on previous legs, we had the opportunity to transfer larger files via satellite with the Kepler system. Normally data were transferred regularly with at least via one overflight per day. This worked reliably except for some very few files which had to be transferred twice. After the update of Kepler system in July, transfer times of upload and download of files was up to 10 times faster. Therefore, the Kepler system was used frequently and mainly to send troubleshooting reports to land and get back precious help how to maintain instruments which did not work properly. The system was further used to transfer scientific data as preliminary results to colleagues on land among other purposes. In total we uploaded 4.24 GBytes and downloaded 2.52 GBytes of data via Kepler system on leg PS122/4.

Data Management:

Besides trainings and assistance in using the provided infrastructure with all its components including fileserver, virtual machines, the sensor registry SENSORWeb and the DSHIP ActionLog, focus of leg PS122/4 data support was also put into consulting scientists regarding the meta data workflow for specific scientific activities more heavily used during the leg PS122/4 including the launches of tethered balloons, recovery of buoys and other instruments. Correct logging of device operations when entering and exiting the 12-mile zone was communicated.

During PS122/4 several software updates provided by the company Zühlke remotely were tested on the FloeNavi infrastructure. This included updates for the FloeNavi Synchronisation Server as well as the FloeNavi Tablets. For testing purposes AIS transponders were installed on the floe. Details to the FloeNavi System can be found in section FloeNavi XXX. The latest version provided (v3.2.1) could not be tested any more due to the breakup of the floe the day after update was delivered. In prior versions there were major issues regarding the grid calculation and display as well as some synchronisation issues which is why the system could not be used during PS122/4. Batch-Import of device operations was therefor only possible by manually created CSV-files from the scientists listing the measurement and sampling actions in the field.

Tasks covered by the data support team included the batch-wise registration of event relations in SENSORWeb based on lists provided by the scientists. Event relations were created for lab analysis data to document with which laboratory instruments field samples had processed or analysed. Event relations were also created for secondary instruments co-deployed in the field together with main sampling or measurement devices which themselves are logged in DSHIP.

Preliminary results

An expedition leg is subdivided into so-called Science Activities in DSHIP, which in turn are composed of numerous device operations. In MOSAiC the weekly schedule for scientific work is represented by weekly incrementing Science Activities. For leg PS122/4 the following Science Activities were defined:

- Science Activity 0: Continuously measuring instruments always running on *Polarstern* (e.g. Ferrybox, Thermosalinograph, etc.) and therefore normally logged by the system administrator.
- Science Activity 43: All continuously measuring or sampling instruments that are deployed on *Polarstern* or the ice for MOSAiC (i.e. buoys, radars, sediment traps amongst others)
- Science Activity 44: Discrete sampling or short-term measurement events performed during the transit phase from Svalbard back to the floe. This Science Activity started on 08.06.2020 after having left the 12-Mile-zone around Svalbard. The first device operation within Science Activity 44 was logged at 22:22 UTC. Science Activity 44 ended on 28.06.2020 when setup of the instruments on the floe was completed and the weekly scientific routine could begin.

- Science Activity 45 - 49: Discrete sampling or short-term measurement events performed within the scope of the weekly scientific schedule starting with Science Activity 45 at 00:00 UTC on 29.06.2020. Generally, a new Science Activity starts at 00:00 UTC every Monday.
- Science Activity 50: All short-term measurement events performed after all data acquisition on floe stopped due to disassemble and recover all instruments shortly and after the breakup of the floe. This last Science Activity of PS122/4 begins on 03.08.2020 and ended on 12.08.2020 at 10:00:00 UTC with the begin of leg PS122/5.

A total of 1614 Device Operations comprising one or more Actions were logged during leg PS122/4.

Altogether, approximately 28.9 Terabytes of data, including 93880 directories and 2.127 Mio. files, were uploaded to the MOSAiC Central Storage on *Polarstern* over the course of PS122/4.

8.3 Media

Lisa Grosfeld[1], Lianna Nixon[1,2],
Susanna Salonen[3], Johannes Spitz[3]

[1] AWI
[2] CIRES
[3] UFA

Objectives

AWI

Comprehensive set of communication activities before, during and after the expedition, including web formats, regular service for news and other daily reporting formats, social media activities, photo and video documentation, exhibition, virtual reality formats, a planetarium show.

During each leg, the **communication manager** coordinates media and outreach requests from shore to ship and vice versa, and ensures a constant service and flow of information to media and the communication departments of participating organizations. The communication manager also create the blog posts for follow.mosaic-expedition.org and social media channels. This person also produces a podcast with the expedition leader in German language and documents the expedition on photos and videos. Since Leg 4, a cooperation with the German Ministry of Finance was established, including the delivery of photos with a special coin showing the imprint “Subpolar Zone” and an explanatory text. The Ministry posts the pictures from the MOSAiC Expedition on their website (https://www.bundesfinanzministerium.de/Content/DE/Bilderstrecken/Sammlermuenzen/2020/2020-08-10-subpolare-zone-muenze-im-eis.html) and Instagram Account (https://www.instagram.com/bundesfinanzministerium/). Similar to that the communication manager was in charge of a second cooperation, with ZDF Logo, including the supply of photos with the figure “Travelino” and text material twice a week for a kid’s blog. “Travelino” is part of the expedition and accompanies the scientists on the ice. He explains to kids what the scientists are experiencing during the expedition and how life is onboard the *Polarstern*.

The **photographer’s** responsibilities include creating a professional pool of photo/video/audio material during her leg and in all conditions that will be made available to the public and also

serve a variety of communication needs. During Leg 4, the photographer supported the communication manager in writing blog posts for follow.mosaic-expedition.org and social media channels.

CIRES

CIRES' objective on Leg 4 was to complete the initial objectives for public engagement and continue the work of Amy Richman, Michael Gallagher, and Christopher Cox, all who have contributed to the planetarium film project during the former legs. The planetarium production about MOSAiC communicates the science, adventure of expedition, and the persistence the scientists face as they navigate the Arctic, arguably one of the world's last final frontiers. To obtain these objectives, the CIRES team collected and created multimedia content that would express shots of the icescape, scientists working, chronologically important events, and joy on the ice were all collected to investigate production methods that would complete our objectives. In addition to this, still photographs were collected to support CIRES' social media and Matthew Shupe's blog entries, which can be found on the website of the American Geophysical Union (AGU).

In addition to this, observations and visuals were collected that could help exploring ideas around the use of virtual technologies in the field, and how intersections of knowing (and funds of knowledge) can further innovate our understanding of the natural world in general public education and outreach. This was done through field observations, journal entries, and interviews with other scientists.

UFA film crew

The German production company UFA produces a 90-minute documentary covering the whole duration of the MOSAiC expedition. The film will be broadcasted on the German TV channel "*Das Erste*" on 16 November 2020. Beside this main film production, additional documentaries are made for international and regional productions. A 45-minute film for the *Rundfunk Berlin Brandenburg* (RBB) will focus on the AWI Potsdam and the MOSAiC expedition and a 45-minute sequence for the *Norddeutscher Rundfunk* (NDR) addresses the crew life onboard Polarstern and participating scientists originating from northern Germany. Another 30-minute film for the *Hessischer Rundfunk* (HR) will be on meteorology and weather models in the Arctic as well as how knowledge is gained based on the MOSAiC sciences. For the swiss television (SRF) a 50-minute film is produced and will be broadcasted in January 2021, emphasizing the contribution of swiss scientists in the MOSAiC expedition. Subsequently, *Freemantle* and the British company *Wild Blue Media* will produce an international film using the UFA footage. With all these films the audience will get an impression of the complex processes of the Arctic climate system as well as how the Arctic impacts the global climate.

Work at sea

AWI

Documenting Leg 4 involved 51 out of 65 photo-shooting days from the communication manager onboard the Polarstern and 103 (everyday) photo-shooting days from the photographer since the beginning of quarantine in Bremerhaven to the last day of Leg 4. Doing so, the entire period starting from quarantine, transit with the ship *Maria S. Merian* and the time on *Polarstern* during the melt season under Polar Day conditions was documented. Thematically, the pictures included research work of scientists on board and on the MOSAiC

floe, old site visits of the original MOSAiC camp, recovery work, other logistical operations and life on board of both mentioned ships and during quarantine.

Targeted photos and videos were produced for the cooperation with the German Ministry of Finances and ZDF Logo.

Subsequently, national and international media outlets have used the MOSAiC photo and video database for reporting about the expedition. In German language, a podcast with chief scientist Markus Rex was recorded and edited. International and national phone interviews of scientists and *Polarstern* crew members, and media requests have been managed onboard *Polarstern*. The major topic of all these requests have been the expedition continuation during corona times, the Leg 3/4 exchange in Svalbard, the expedition progress after returning to the MOSAiC floe and the end of the lifecycle with the breakup of the floe.

In addition, the communication manager coordinated and wrote 65 blog posts in English and German with support of the photographer.

Besides these media responsibilities, the team regularly supported and assisted the work of the scientific groups on the ice, acted as bear guards at the different camp sites and were lookouts on the ship's bridge, all together guaranteeing the success of all science activities during Leg 4.

CIRES

It was very important for the CIRES team to capture life onboard the ship and the work of the scientists throughout Leg 4. As we endured quarantine and sailed up to Svalbard on the *Maria S. Merian* and *Sonne*, Lianna took this time to conduct initial interviews and get to know the scientists who would be furiously working on the ice we arrived to the *Polarstern*. While doing this work, Lianna was able to investigate what kinds of research interests the scientists were excited to investigate, what they were looking forward to around the melt season and Arctic summer, and explore how identity plays a role in science. In addition to this, Lianna started working with scientists on artistic illustrations that show analogies they have for the sake of joyful science communication, a concept she has been working on throughout her Master's Degree.

Upon boarding the *Polarstern* and working on the floe, Lianna followed scientists out into the field with 360 VR equipment and 2D still and film cameras. She collected shots that depicted work setting, working on the ice, and interviews, depending on the situations on the ice.

As Lianna filmed on the ice, her strategy and filming styles changed. She began to focus on ice features and the rapidly changing arctic icescape the scientists interacted with. Each day the floe, which was so familiar to many, changed in its colors, natural state changes, shapes, and ice formation/degradation.

There was also a lot of experimentation in underwater filming tactics on the ice. Lianna designed a bamboo stick that would hold the 360 housing to reach depths beyond 2-meters. The instrument that she kindly named Cole was narrow enough to go into coring holes. This too became useful for scientists who wanted to see real-time footage of the sea ice underneath and what they were drilling.

The precipitation and wetness of the Arctic was perhaps the greatest challenge for the equipment. Fog would create condensation on the 360-lenses.

For general CIREs outreach, she took photos that were based off of Matthew Shupe's journal entries that are being posted on the AGU website. Similar to photojournalism assignments, Lianna used techniques to capture what worked best for the blog posts. In addition to this, one

insta-360 mini in a housing and a clamp system was lost to the sea and another insta360 mini was damaged during a storm.

UFA film crew

On Leg 4 the UFA collected many hours of video and audio footage on the ice and on board *Polarstern*, as well as during quarantine and during the transit phase and team exchanges. The material is in German, Swiss, English, Finnish and Russian.

Preliminary (expected) results

AWI

At the beginning of Leg 4, the focus of the media requests were the challenges for the continuation of the expedition during the global corona pandemic and the success message about the possibility to continue the expedition with help of the two German research vessels *Maria S. Merian* and *Sonne*. All this was also content for a press conference in the German Ministry of Education and Research in May. Here the AWI director Antje Boetius was on site and a live conference to Markus Rex and Torsten Kanzow from board *Polarstern* in the fjord of Svalbard was established. Later during Leg 4 the arrival back at the MOSAiC floe, the turn down of the ice camps, and the historical low of sea ice concentrations in the Arctic were focus of AWI press releases:

18 May: “New MOSAiC team now bound for the Arctic”

18 June: “*Polarstern* returns to the MOSAiC floe”

6 July: “The latest findings on the MOSAiC floe”

27 July: “Sea-ice extent in the Arctic at a historical low”

31 July: “Time to Say Goodbye”

Regarding to the Monitoring method, the international media reach for the key word “MOSAiC” was 450 Million during the period of leg 4. The media coverage includes Articles in Bloomberg Green, Washington Post (USA), El País (Costa Rica), National Geographic (Hungary), The Times of India, Turun Sanomat (Finland), ZEIT Online (Germany) and Tagesspiegel (Germany).

During Leg 4, we had 17,700 followers on Instagram (on 12.8.2020) and 9,400 followers on Twitter (on 12.8.2020). 70,000 monthly visitors followed the official MOSAiC blog on www.follow.mosaic-expedition.org.

Since the cooperation with ZDF Logo started, the online “Travelino” blog for kids was established after a teaser in the kid’s news show “Logo” on the German TV channel “KiKa” advertised the new blog: https://www.zdf.de/kinder/logo/travelinos-tagebuch-von-der-polarstern-100.html.

Regular posts including pictures with the coin “Subpolare Zone” placed in a MOSAiC environment have been published on Instagram and the website of the German Ministry of Finances (https://www.bundesfinanzministerium.de/Content/DE/Bilderstrecken/Sammlermuenzen/2020/2020-08-10-subpolare-zone-muenze-im-eis.html).

CIRES

Overall, content collection was a success for the planetarium. Matthew Shupe wrote and posted numerous blogs on the AGU website, as a continued project he started on Leg1, with photos taken by him and Lianna Nixon.

Overall, Lianna collected 38,745 still photos, 2 TB of non-360 video content, and 9 TB of 360 content from the Large insta-360 pro II and Insta 360-minis from 1 MAY 2020 to 11 AUGUST 2020. Content collected was of all scientists onboard the *Polarstern* for Leg 4 and of some crew and officers.

For Lianna as both filmmaker and Education researcher, she was analyzing and exploring the ways 360-technology can as an interdisciplinary strategy as an instant infield scientific feedback tool and media outreach. The Insta360-cameras have live recording software, allowing one to look at a cell phone to see what the camera sees. Lianna was asked to specifically film, for the sake of feedback, off-floe instrument recovery, First Year Ice coring, and remote sensing instrument management events. This allowed scientists to see what they were doing in real time underneath the ice's surface. The camera also became a tool for immersive scientific observations, for instance, capturing the fresh water lens. Using the 360 camera allowed scientists to see the entire icescape below, it was fascinating to collaborate with scientists in the intersection between 360-filmwork and the needs for it in the field. It not only became a feedback tool, but it also helped scientists be able to see how in-field media collaboration can be a powerful tool in communicating their science. This notion of interdisciplinary media/science allows us to explore how we can close the art-science gap in the field and use virtual interfaces as a platform for innovating science and media strategy. When we are able to intersect two different ways of investigation and knowing, we can continue to challenge the ways we are conducting ourselves in the field or in our own inquiry. Lianna is also curious to see how this process helps with understanding the metacognitive experience on what scientists are doing on the ice and the field, how might these tools impact one's thought processes and actions in the field, and in what ways this kind of processing allow us to better learners of the Arctic environment. She will continue to ask these questions and push what it means to create authentic intersections between media, communication, and science so that we may further innovate our ways of knowing in the field and how they translate to public outreach.

UFA

The high quality and low compression of the images results in a big amount of data. About 32 TB of material are on the hard disks. The postproduction will take place in Potsdam, Cologne and London. Here, the aim is to tell exciting stories about persons, their hopes and feelings, victories and failures, laughing and sadness, curiosity and hard work, in order to get the best results out of a limited time in the Arctic.

During our filming on *Polarstern* the UFA team focused on the following protagonists:

Team Atmos: Matthew Shupe, Alexander Schulz, Michael Lonardi, Christian Pilz, Julian Hofer

Team Ocean: Kirstin Schulz, Ingo Schuffenhauer, Morven Muilwijk

Team Eco: Allison Fong, Giulia Castellani, JP Balmonte, Katy Shoemaker

Team Ice: Benjamin Lange, Amy MacFarlane, Evgenii Salganik, Felix Linhardt, Igor Sheikin, Ilkka Matero, Madison Smith, Ian Raphael

Chief scientist Markus Rex

Captain Thomas Wunderlich

Crew members of the Polarstern: Irina Wartenberg, Jacob Langhinrichs, Michael Fölster, Wulf-Dieter Miersch

Data management

AWI

After arrival of the leg 4 team on land, a selection of the produced photo and video material will be uploaded to the media libraries multimedia.awi.de/mosaic (photos), and multimedia.awi.de/mosaicvideo (videos). This material will be made available under a creative commons license to support all MOSAiC partners as well as journalists.

CIRES

The content produced by the photographer for both AWI and the CIRES production was managed daily along with equipment. V/A multimedia content that was produced from non-360 cameras was archived on hard drives. Still photographs were organized on the Lightroom through a catalog workflow. High-resolution JPEG photos were provided to the server under Picture of the Day.

For 360-content, footage that was collected was uploaded to hard drives provided by CIRES located in the CIRES Atmos container on the bow. Hard drives with Leg 4 footage will stay on board for leg 5 and will return at the end of Leg 5.

8.4 Leads

Maddie Smith[1], Alli Fong[2], Morven Muilwijk[3], Sandra Tippenhauer[2], Deborah Bozzato[4], Oliver Mueller[3], Alessandra D'Angelo[5], Emelia Chamberlain[6], Steve Archer[7], Melinda Webster[9], Katy Shoemaker[5], Aikaterini Tavri[8]

[1] UW Seattle

[2] AWI

[3] University of Bergen & Bjerknes Centre for Climate Research

[4] University of Groningen

[5] University of Rhode Island – Graduate School of Oceanography

[6] Scripps Institution of Oceanography – University of California San Diego

[7] Bigelow Labs

[8] University of Victoria, Canada

[9] University of Alaska – Fairbanks

Objectives

Lead properties and processes play a key role in the evolution of other components of the system. During the summer, open water leads provide a key connection between the ocean and atmosphere for input of light, heat, and flux of gases. Cross-cutting opportunistic lead sampling was undertaken in order to characterize the impact of these processes on key questions motivating each of the science teams. The questions addressed by each team were generally as follows:

- ICE: How is heat partitioned between the upper ocean and sea ice? What is the role of near-surface stratification in leads in controlling the partitioning of heat and sea ice melt?
- OCEAN: 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?

- ECO: How does freshwater melt, upper ocean stratification, and differences in light and nutrient regimes of leads control microbial and small faunal distributions and processes?
- BGC: What is the concentration of climate relevant trace gases (CRTG) in leads and how is their migration affected by the upper ocean stratification? What is the role of phytoplankton biomass/distribution on DMSP production and what is the potential for microbial oxidation of methane in these environments?
- ATMOS: What are the flux rates between the atmosphere and ocean in leads, and how are they controlled by the evolution of the near-surface stratification?

Lead sampling had strong linkages to many interdisciplinary questions within the MOSAiC science plan.

Work at sea

Below we describe the general sampling methods used by each of the teams. Lead work was approached in an interdiscplinary manner when possible, with collocated observations from many teams occurring at the same site. Individual teams made additional measurements of leads, which are also described here.

Site descriptions

Five different lead sites were visited throughout the Leg in order to capture the spatial heterogeneity of processes.

- ROV lead: The area in front the ROV hut was visited twice early in the leg. This had the added benefit of collocation with ROV measurements (including CTD profiles, multibeam surveys, and video footage – see section 4.5 for more details). This lead was not revisited after ship repositioned and disturbed the area on 12 July.
- Site A: Narrow, typically brash-filled lead at the 0 m position on Lemon Drop albedo line.
- Site B: Approximately 60 m wide lead surrounded primarily by level, first-year ice.
- Site C: Approximately 30 m wide lead next to first-year ice near Drone-ville.
- Site D: Typically a large (~100 m wide) lead with some discrete blocks near Alli's Ridge.

Approximate locations of the sites are shown in Figure 8.4.1, with photos of some of the sites in Figure 8.4.2.

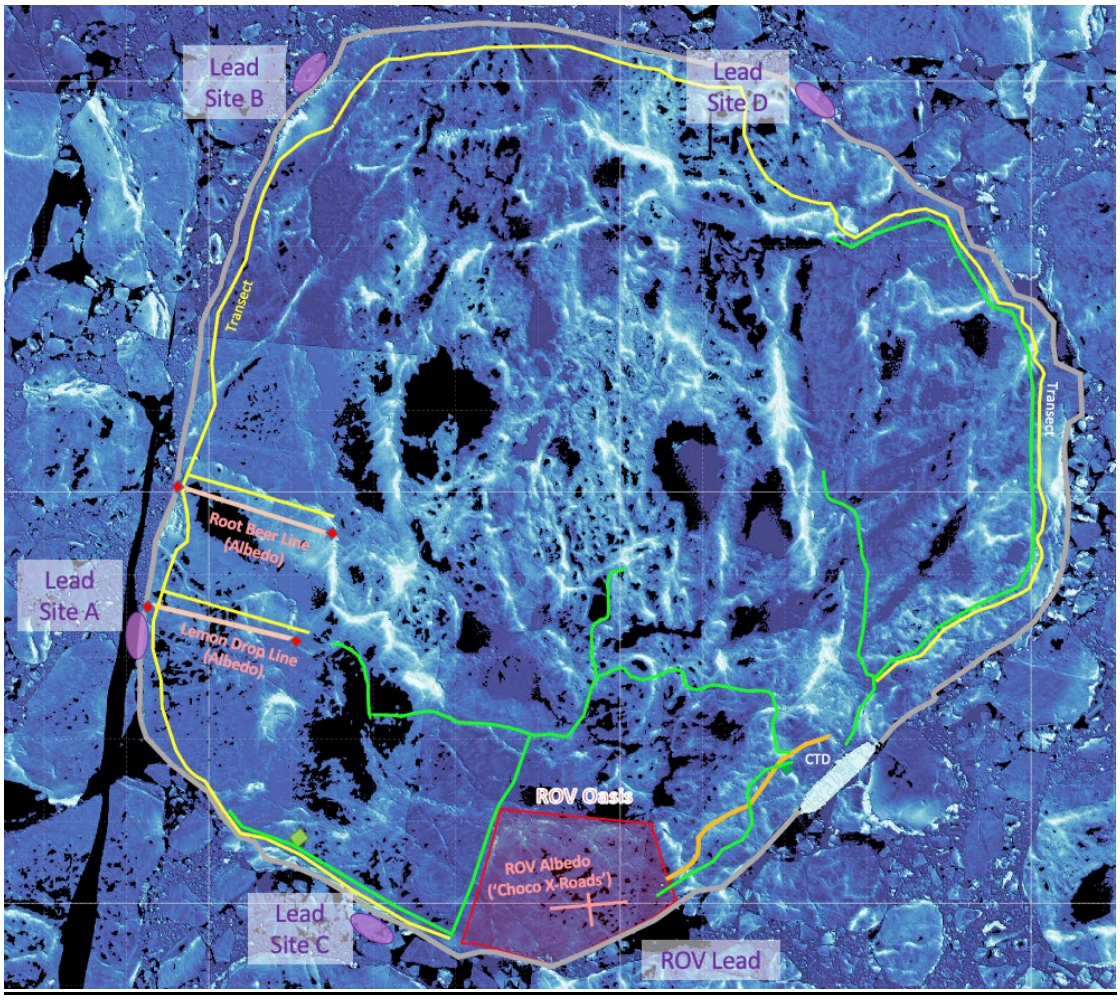

***Fig. 8.4.1**: Map of approximate lead sampling sites (in purple).*

***Fig. 8.4.2**: Photos of Lead Site A (left), Site C (center), and Site D (right) on 22 July (A & C) and 24 July (D). Photos: M. Smith*

<u>Near-surface fresh layer</u>

In order to understand how heat is partitioned between the upper ocean and sea ice, observations of temperature and salinity were made under-ice and in leads surrounding the floe (Team ICE). Profiles were made using a combination of point measurements in the upper 1-2 meters with a YSI Professional temperature and conductivity probe, and profiles in the upper 25-30 meters using a Sontek Castaway. We typically aimed for 4-6 distributed profiles per site in order to understand the spatial heterogeneity of structure. Profiles were done both from the ice edge and from small vessels (pontoon floats or sea kayaks). This work is linked to the under ice freshwater lens and false bottom sampling, described in section 4.13.

Additional CTD profiles were made by Team OCEAN using a Sea&Sun M48 on a fishing-rod (referred to as the fishing-rod CTD) (PI Sandra Tippenhauer, AWI)

Imagery

Characteristics of leads were captured with a few types of imagery:

- GoPro video profiles of the upper meter of lead observation sites, to observe fresh lens and characterize turbidity
- RGB and hyperspectral imagery of leads from helicopter
- Sites were also characterized with photographs and written descriptions.

Turbulence profiling

Profiles of turbulence and temperature were made in leads using a VMP250 Upriser (PI Ilker Fer, University of Bergen) down to 60- 80 m, depending on the drift speed. The instrument is equipped with 2x shear sensors, as well as microconductivity and temperature sensors.

Fig. 8.4.3*: Left: VMP250 Upriser being deployed in lead (Photo: Lianna Nixon). Right: Upriser at the surface after making a profile at Lead Site D, on 28 July (Photo: M. Smith).*

Water sampling

ECO: The observations aim to measure standing stocks of organisms and organic matter (chl a, POC/PON); microbial, protistan, and microzooplankton diversity and abundance (light microscopy, FCM, net tows, DNA); production rates in relation to nutrient availability (PP, BP, nuts) from 3 shallow horizons. These properties influence production, sequestration and fluxes of gases across the ice, ocean, and atmosphere interfaces.

- NPP and BP rates – primary productivity and bacterial production (if possible)
- Total DNA – microbial diversity
- Light Microscopy – plankton taxonomy
- Flow cytometry – single cell organism enumeration

- Chlorophyll samples – photosynthetic biomass
- Particulate Organic Carbon and Nitrogen concentrations (POC/PON) – suspended organic matter concentrations (living and dead stuff)
- Inorganic Nutrient concentrations – nutrient availability and recycling processes
- FRRf – photosynthetic efficiency and fitness (if possible)
- Plankton net tows - plankton diversity, abundance, distribution, and biomass (if possible)

BGC: Observations aim to investigate biogeochemical cycling of CRTG in leads. The concentrations and isotopic ratios of CRTG were measured in parallel to phytoplankton pigment distributions and microbial community structure. According to water characteristics (i.e. visible biomass and/or stratification within temperature and salinity profiles), samples were collected from each water feature (~3 horizons) for the following parameters:

- Chlorophyll *a* fluorescence (PAM & FRRf when not sampled by ECO) to determine the photosynthetic efficiency and fitness (See Section 7.3)
- Light microscopy (mainly, if not sampled by ECO) – plankton presence/taxonomy (See Section 7.3)
- Total dimethylsulfoniopropionate ($DMSP_t$) production (See Section 7.3)
- In-situ Methane (CH_4) and Carbon Dioxide (CO_2) concentrations and isotopic signature; experimental incubation for CH_4 oxidation potential (See Section 7.2)
- Total DNA and/or RNA to capture microbial diversity using 16s/18s amplicon sequencing (See Section 7.2)
- ^{18}O and Deuterium isotopic signatures (See Section 7)

<u>Flux rates</u>

A dynamic flux chamber (Figure 8.4.9(a)) was used to measure exchange rates of CO_2, CH_4 and DMS across the air-sea interphase. More details of the approach and deployment frequency of the flux chamber are given in the main Atmosphere section of the report. Alongside each of the flux deployments and on the two lead-sampling dates (17/7/20 and 22/7/20), near-surface profiles of DMS and salinity were obtained using a syringe and teflon-lined aluminium tubing. 'Surface' samples were taken by gently inverting a falcon tube to obtain the upper few millimeters of the water column. Aqueous DMS concentrations were determined using a purge-and-adsorbent trap combined with automated thermal desorption system linked to a GC-FPD. Salinity of each of the analysed samples was obtained using the YSI salinity/conductivity probe.

Tab. 8.4.1: Device operations and associated ECO/BGC/ATMOS/OCEAN water sampling from lead surveys

Date	ActionLog_ID	Lead	Samples taken
01/07/20	PS122/4_45-120 water_probe PS122/4_45-52 Castaway PS122/4_45-186 GoPro	ROV	1 horizon: Chl*a* fluorescence (PAM and FRRf), light microscopy – BGC 10 Castaway profiles
09/07/20	PS122/4_46-102 Castaway PS122/4_46-103 YSI		4 Castaway & YSI profiles
10/07/20	PS122/4_46-162 water_probe	ROV	3x horizons: DMSPt, Chl*a* fluorescence (PAM), CH_4 - BGC, ECO: Chl*a* concentration, nutrients

11/07/20	PS122/4_46-161 water_probe	ROV	3x horizons: Chl*a* fluorescence (PAM), $DMSP_t$, CH_4/CH_4 incubation, DNA/RNA - BGC
17/07/20	PS122/4_47-145 peristaltic_pump PS122/4_47-121 Castaway PS122/4_47-181 YSI PS122/4_47-182 GoPro PS122/4_47-160 water_probe	A	3x horizons: Chl*a* fluorescence (PAM), light microscopy, $DMSP_t$,, CH_4 (2x horizons), DNA – BGC ECO: Chl*a* concentration, nutrients 5 Castaway & YSI profiles 3x horizons: DMS, (BGC & ATMOS) 1x horizon: CH_4
17/07/20	PS122/4_47-146 peristaltic_pump PS122/4_47-109 Upriser PS122/4_47-122 Castaway PS122/4_47-183 YSI PS122/4_47-184 GoPro PS122/4_47-161 water_probe PS122/4_47-109 Upriser	B	3x horizons:, Chl*a* fluorescence (PAM), light microscopy, $DMSP_t$,, CH_4, DNA – BGC ECO: Chl*a* concentration, nutrients 5 Upriser profiles (OCEAN) 4 Castaway & YSI profiles 3x horizons DMS (BGC & ATMOS) 3 Upriser profiles (OCEAN)
18/07/2020	PS122/4_47-110 Upriser	D	10 Upriser profile (OCEAN)
20/07/2020	PS122/4_48-8 Upriser PS122/4_48-102 fishing rod CTD	D	14 Upriser profile (OCEAN) 2 fishing rod CTD profiles (OCEAN)
21/07/2020	PS122/4_48-31 Upriser PS122/4_48-103 fishing rod CTD	D	12 Upriser profile (OCEAN) 1 fishing rod CTD profiles (OCEAN)
22/07/20	PS122/4_48-111 peristaltic_pump PS122/4_48-200 Castaway PS122/4_48-199 YSI PS122/4_48-201 GoPro	C	3x horizons: Chl*a* concentration, Chl*a* fluorescence (PAM), nutrients, light microscopy, $DMSP_t$, ^{18}O, CH_4, DNA – BGC, DMS (BGC & ATMOS)
22/07/20	PS122/4_48-112 peristaltic_pump PS122/4_48-203 Castaway PS122/4_48-202 YSI PS122/4_48-204 GoPro	A	3x horizons: Chl*a* concentration, Chl*a* fluorescence (PAM), nutrients, light microscopy, $DMSP_t$, ^{18}O, CH_4, DNA – BGC, DMS (BGC & ATMOS)
22/07/20	PS122/4_48-113 peristaltic_pump PS122/4_48-67 Upriser PS122/4_48-206 Castaway PS122/4_48-207 YSI PS122/4_48-205 GoPro	D	3x horizons: Chl*a* concentration, Chl*a* fluorescence (PAM), nutrients, light microscopy, $DMSP_t$, ^{18}O, CH_4, DNA – BGC, DMS (BGC & ATMOS) ECO: Chl*a* concentration, nutrients 6 Upriser profile (OCEAN)
28/07/20	PS122/4_49-77 water_probe	D	1x horizon: Chl*a* fluorescence (PAM), $DMSP_t$, ^{18}O, DNA (all BGC),

	PS122/4_49-114 Upriser PS122/4_49-69 Castaway PS122/4_49-68 YSI PS122/4_49-70 GoPro		DMS (BGC & ATMOS) + glycerol stock sample 1 Upriser profile (OCEAN) 1 Castaway & YSI profile

Preliminary results

Near-surface fresh layer

In total, we had 7 days of observation in leads with the Castaway at various locations. We generally observed warming and freshening of the upper ocean (appr. 10-15 meters) over time. The observed temperatures were typically greater than the freezing temperature, indicating potential for ice melt.

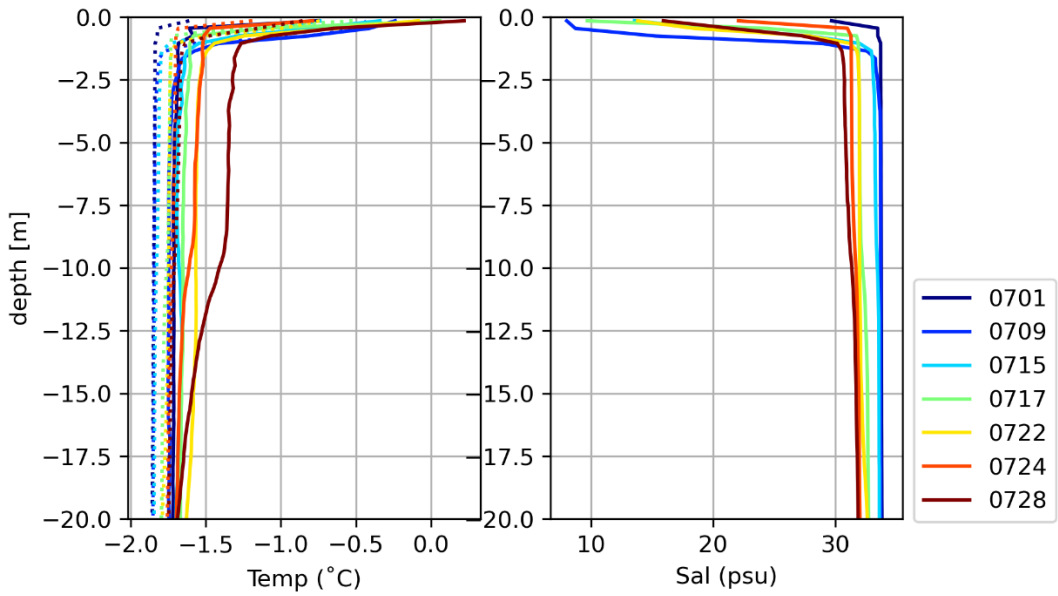

***Fig. 8.4.4**: Average profiles of temperature (left) and salinity (right) in upper 20 meters of leads measured with Sontek Castaway. Profiles are colored by date, from 1 July (blue) to 28 July (red). Dotted lines show approximate average freezing temperature for each day. Results shown are using the automatically processed results from the Castaway software, and will be refined using the raw data. Figure: M. Smith*

We had 5 days with detailed profiles of the upper 1-2 meters in leads with the YSI at various locations. The fresh surface layer (< appr. 20 psu) varied in depth, from about 30 cm (e.g. light blue profile in Figure 8.4.5) to more than a meter.

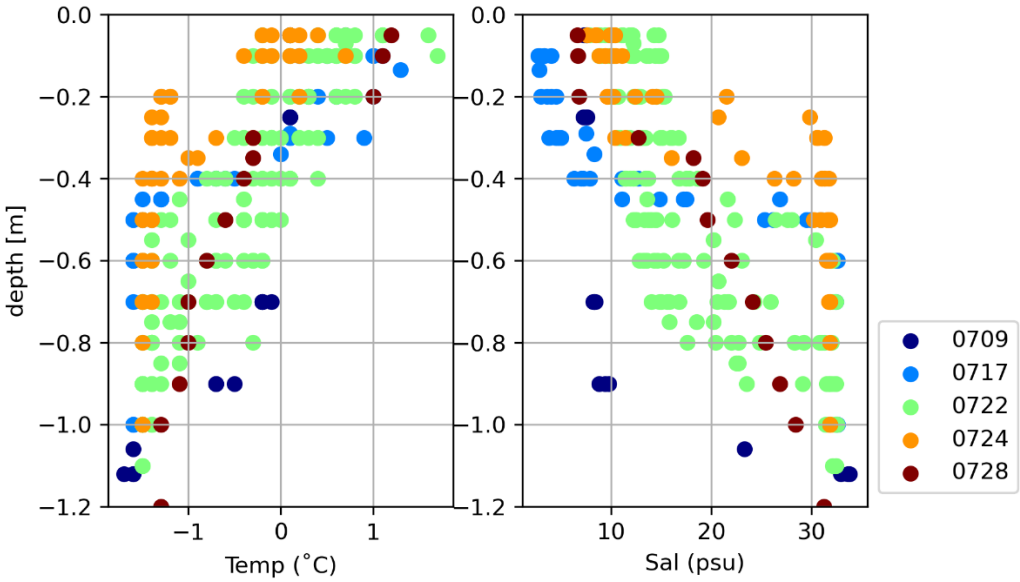

***Fig. 8.4.5**: All measurements of temperature and salinity in upper 1.5 meters of leads with YSI probe. Points are colored by day, from 9 July (blue) to 28 July (red). Figure: M. Smith*

<u>Imagery</u>

In total, 27 GoPro surveys at lead sampling sites were completed. These videos provide visual confirmation of the halocline at the base of fresh layers, and show an increase in biological activity and turbidity in the water (Figure 8.4.6).

***Fig. 8.4.6**: Screenshots from GoPro videos of leads on 1 July (left) and 29 July (right). Fresh water lens was visibly deeper, the water more turbid and green, and significantly more visible biomass. Photos: M. Smith*

Water sampling

BGC: the presence of biomass was visibly different between the sites. Chl*a* fluorescence (PAM & FRRf) values confirmed a good phytoplankton fitness in the so called creamy layer (visible from the surface) and in the water column underneath (approx. 1m), as well as light microscopy images (Figures 8.4.7 & 8.4.8).

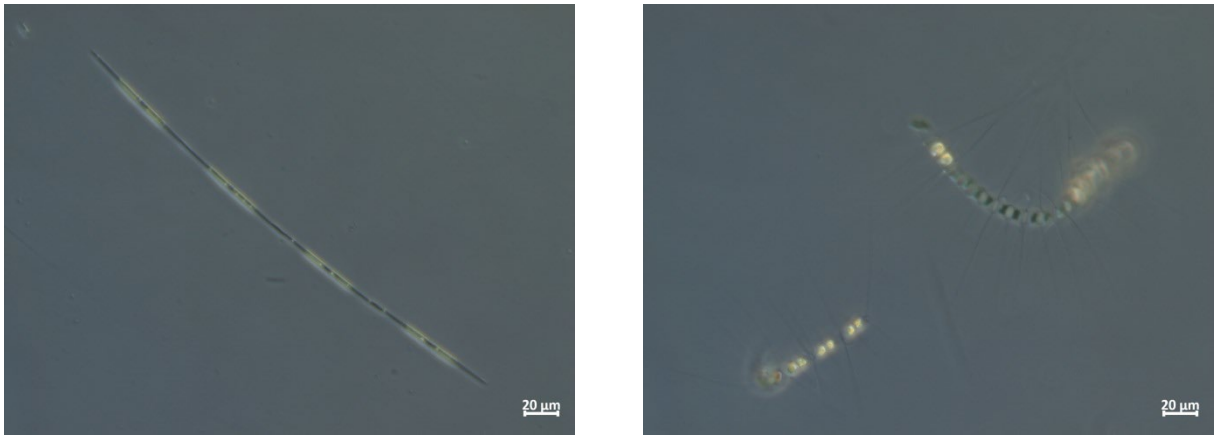

Fig. 8.4.7*: Microscope pictures of lead samples on 17 July, diatoms species are recognisable (left: Pseudo-nitzschia, right: Chaetoceros). Photos: D. Bozzato*

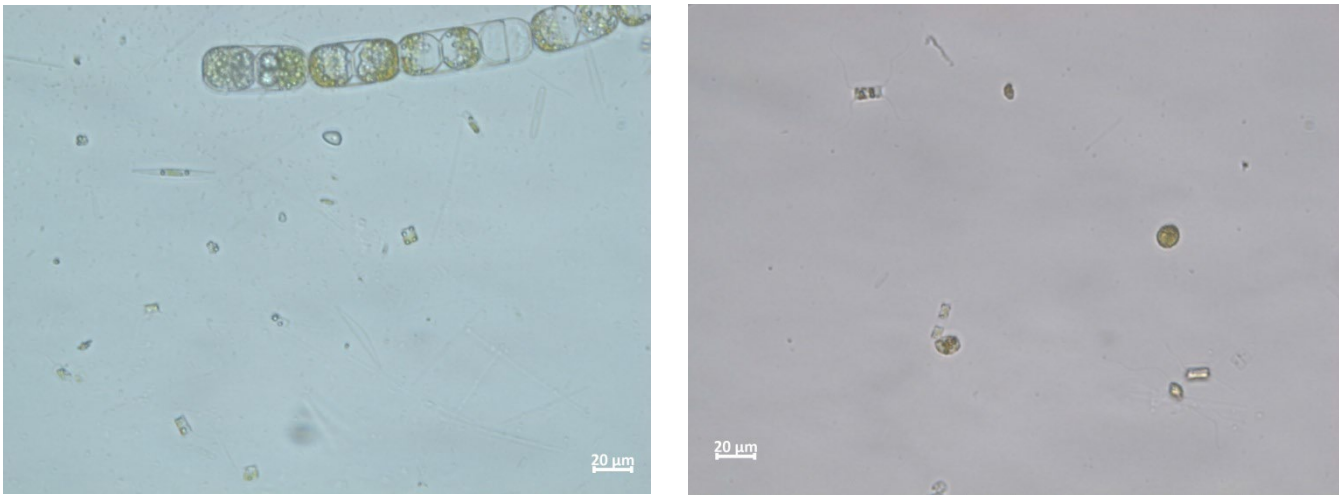

Fig. 8.4.8*: Microscope pictures of lead samples from 1 July. A number of different species are recognisable, including a Melosira chain in the picture on the left (on the top right). Photos: D. Bozzato*

ATMOS: The freshwater lens that had developed in the leads by mid- to late-June, acted as an effective barrier to biogenic gas flux between the biologically active sea surface and atmosphere. As shown in Figure 8.4.9(c), considerably lower concentrations of DMS occurred at the air-water interface than existed in the underlying seawater, resulting in decreased emission to the atmosphere. One step to potentially parameterize the effect of the freshwater on gas flux, is to relate gas concentrations to salinity. As shown in Figure 8.4.9(b), salinity explains some of the the variability in aqueous DMS concentrations. Our aim is to better understand the temporal and spatial variability of the melt water influence on surface gas concentrations and attempt to incorporate that in models of gas exchange over ice covered ocean.

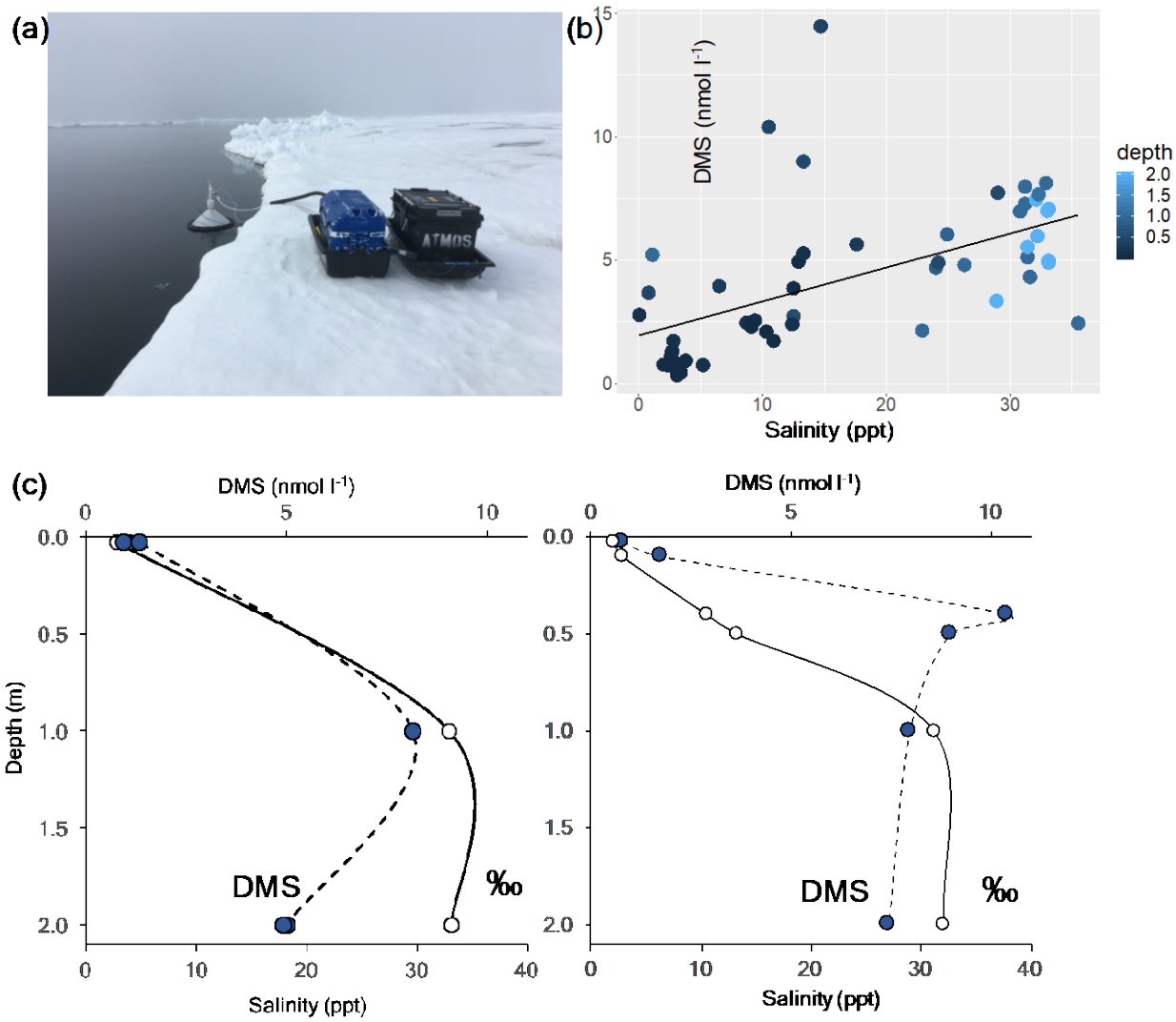

***Fig. 8.4.9**: Trace gas measurements in open leads: (a) Floating chamber and analysers; (b) DMS vs. salinity in the upper 2 m of open leads mid- to late-July , regression F-statistic p-value = 1.0 x10^{-5}; (c) depth profiles of DMS and salinity on 14 and 17 July. (Fig: Steve Archer)*

<u>Turbulence</u>

OCEAN: The VMP250 Upriser turbulence probe was deployed in leads on six different occasions. Three stations were occupied as part of a combined sampling effort with the teams ICE/ECO/BGC/ATMO, and three stations were occupied by team OCEAN only. Figures 8.4.10 and 8.4.11 show preliminary results of temperature and mixing rates from a selected set of profiles from the six different stations. Preliminary data processing was performed onboard using the MATLAB toolbox provided by PI Ilker Fer. Final data processing and quality control will be performed by Ilker Fer. Temperature profiles presented in Figure 8.4.10 generally show relatively warm surface waters, varying between -1.5 and 0°C. Generally, there are small variations in temperature and mixing rates throughout the upper 60m of the water column, with an exception of slightly elevated mixing rates in the upper 15 m and at 35 m depth. The elevated mixing rates in the upper 15 m was a feature that was observed during all six lead sampling events, with the lowest near surface values on the 20.07.2020 and 28.07.2020. On 18.07.2020 a warming of almost one degree Celsius in the upper 60 m was observed throughout the duration of the station. This warming was accompanied by increased mixing. Further postprocessing and quality control of the data is needed before any conclusions can be drawn about this feature.

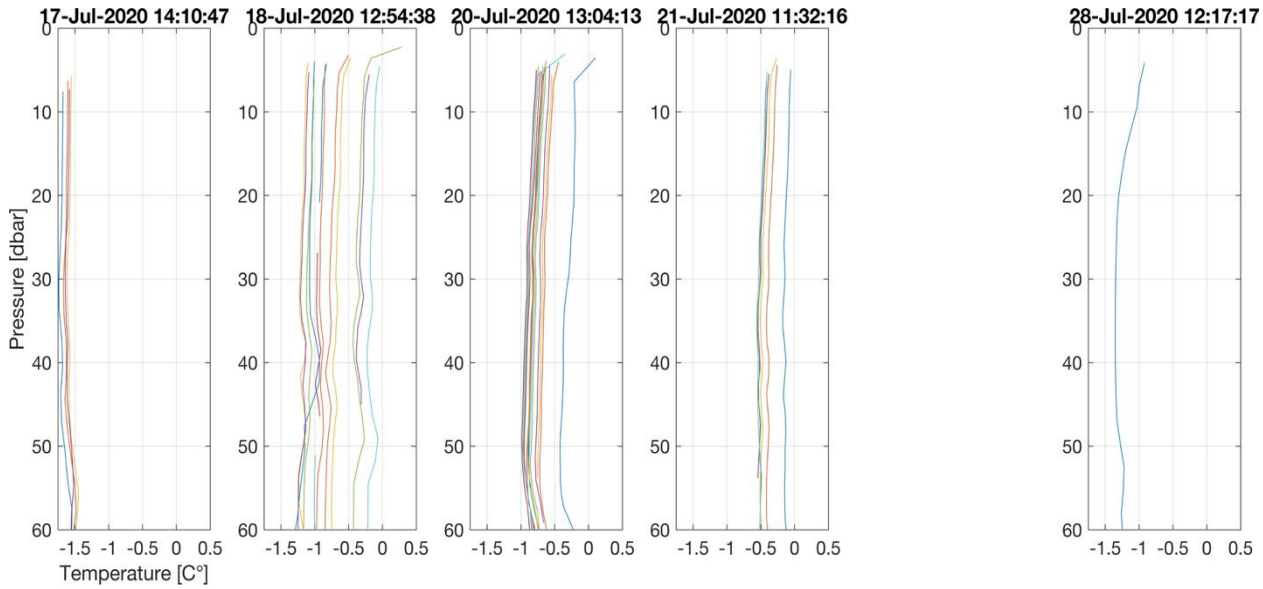

***Fig. 8.4.10**: Preliminary temperature profiles observed from the VMP250 upriser during the 6 lead sampling events where it was deployed. The date of the sampling is given at the top of each panel. Plot by Sandra Tippenhauer.*

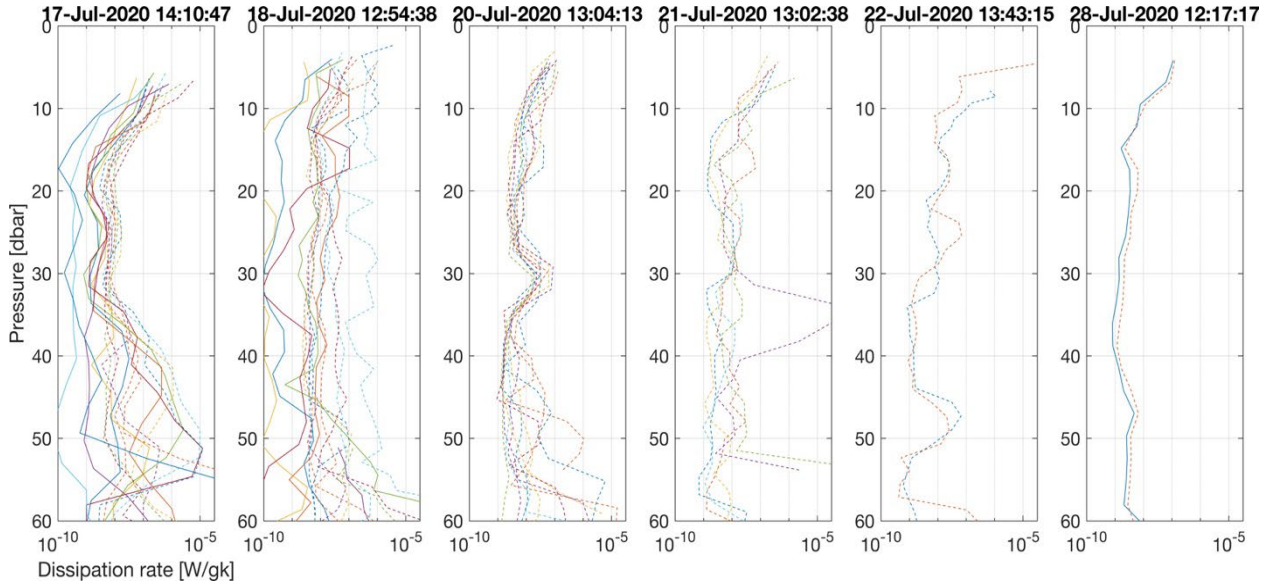

***Fig. 8.4.11**: Preliminary dissipation rate observed from the VMP250 upriser during the 6 lead sampling events where it was deployed (Solid line – Shear sensor 1, dashed line – shear sensor 2). The date of the sampling is given at the top of each panel. Plot by Sandra Tippenhauer.*

Device URNs

Castaway: **pack_ice:ice_ps**:uw_castaway_cc1415003

YSI: **pack_ice:ice_ps**:dart_ysi

GoPro: **camera**:uw_gopro

VMP250 Upriser: **pack_ice:ice_ps**:uib_vmp250

Fishing-rod CTD: **pack_ice:ice_ps**:ctd_48m_1459

Peristaltic Pump: **pack_ice:ice_ps**:peristaltic_pump

8.5 CORING

NOT AVAILABLE