

## Preliminary Cruise Report to the Directorate of Fisheries, Norway

to

conduct marine scientific research in the central Arctic

**Name of the research ship:** RV POLARSTERN

**Cruise No.:** PS122/3, PS122/4, PS122/5

**Dates of the cruise:** 24.02.2020 – 12.10.2020

**Operating Authority:**

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### NOTIFICATION

The Multidisciplinary drifting observatory of the study of Arctic Climate (MOSAiC) expedition (PS122) was the largest Arctic research expedition of all times. This includes the lengths of the expedition, the scientific measurements and the number of scientists involved, the logistical effort and the costs. Organizing and analyzing the collected data and samples is a big task and will take the next several years up to the next decades. After the successful expedition, we are working hard to develop comprehensive and detailed cruise reports for the five legs of PS122. However, MOSAiC will not be able to hand in the reports within six months after the end of the expedition. Writing the reports in a professional and adequate way, will take time. For now, MOSAiC submits a preliminary report and plans to hand in the final cruise reports to the Directorate of Fisheries by the end of 2021.

### INTRODUCTION

The Multidisciplinary drifting observatory of the study of Arctic Climate (MOSAiC) expedition (PS122) was the largest Arctic research expedition of all times and was performed from September 20<sup>th</sup> 2019 to October 12<sup>th</sup> 2020. The German research icebreaker RV Polarstern started on September 20<sup>th</sup> 2019 from Tromsø (Norway) and was accompanied by the Russian icebreaker Akademik Fedorov that left Tromsø port on September 21<sup>st</sup> 2019. Both vessels entered the Siberian sector of the Arctic and looked for a suitable ice floe that RV Polarstern could use to dock on for an entire year. On October 3<sup>rd</sup> 2019, the MOSAiC floe was detected at 85°N and 137°E and one day later, RV Polarstern docked on the floe and the drift started. With the arrival at the floe, the set up of the ice camp on the ice floe began with tons of equipment and scientific instruments. In the meantime, Akademik Fedorov was responsible to bring out the distributed network meaning stations with autonomous working instruments within a distance of up to 50 km away from RV Polarstern. Both, RV Polarstern at the ice floe and the distributed network drifted across the polar cap towards the Atlantic Ocean (see Fig. 1).

The MOSAiC expedition was planned with six legs, each approximately two months long. Due to the fast drift and travel difficulties due to the COVID-19 pandemic, the schedule of the expedition was adjusted. A planned exchange with aircrafts via Svalbard in beginning of April 2020 was not possible and had to be canceled. Instead, the exchange was performed by ship mid of May 2020 in the Isfjord of Svalbard and RV Polarstern needed to leave the ice floe. The postponed exchange lead to a rescheduling of the expedition that finally was performed with five cruise legs instead of six (see table 1 for dates after rescheduling).

After RV Polarstern left the ice floe for the exchange between Leg 3 and Leg 4, the vessel arrived back in the ice mid of June 2020 and continued the measurements at the original ice floe. The fast sea ice drift lead to an early breakup of the floe at the ice edge end of July 2020. This event was combined with the last exchange performed with the Russian icebreaker Tryoshnikov. After the exchange, RV Polarstern head up north and crossed the North Pole while looking for a new ice floe. The rest of the expedition was performed at the new ice floe and end with entering the port of Bremerhaven in the morning of October 12<sup>th</sup> 2020.

Tab. 1: PS122 schedule after reorganization and with five legs.

Leg 1	20.09.2019 – 13.12.2019
Leg 2	13.12.2019 – 24.02.2020
Leg 3	24.02.2020 – 04.06.2020
Leg 4	04.06.2020 – 12.08.2020
Leg 5	12.08.2020 – 12.10.2020

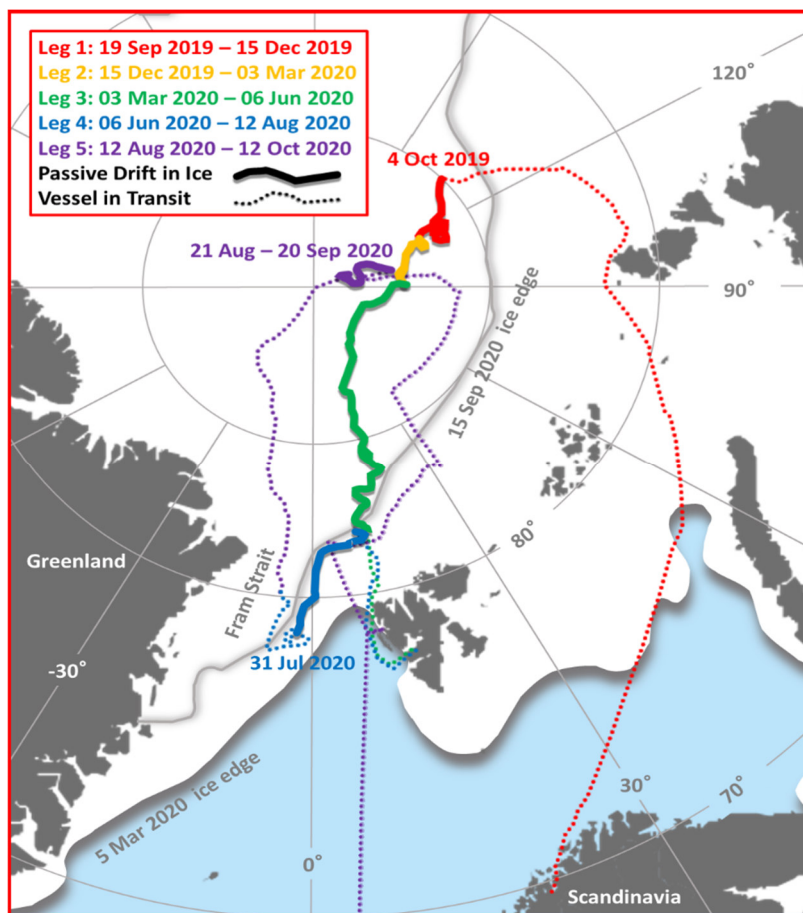


Fig. 1: Cruise track from September 20<sup>th</sup> 2019 – October 12<sup>th</sup> 2020 (Taken from Shupe et al. 2020: DOI: 10.25923/9g3v-xh92)

## REFERING TO THE NOTIFICATIONS AND AUTHORISATION

In February 2020, AWI submitted the notifications of proposed research cruises for the originally planned cruise legs PS122/4 (April 1<sup>st</sup> 2020 – June 15<sup>th</sup> 2020), PS122/5 (June 16<sup>th</sup> 2020 – August 15<sup>th</sup> 2020) and PS122/6 (August 16<sup>th</sup> 2020 – October 12<sup>th</sup> 2020) to perform research in territorial waters of Norway. In April 2020, AWI submitted an adjustment explaining the changed cruise schedule caused by the COVID-19 pandemic to the Office of Federal Foreign Affairs. This adjustment as well included the request for a Portcall in the Isfjord of Longyearbyen from May 23<sup>rd</sup> 2020 – May 28<sup>th</sup> 2020 to allow the resupply with provision, equipment and the bunkering of fuel and the exchange of the crew and scientists with the German research vessels Maria S. Merian and Sonne.

With the updated schedule of the expedition (see Tab. 1), the notification of proposed research cruise covers now the cruise legs PS122/3, PS122/4 and PS122/5 which cover a time period from February 24<sup>th</sup> 2020 until October 12<sup>th</sup> 2020. This preliminary cruise report, refers to the mentioned time period and the cruise legs.

## PURPOSE OF RESEARCH DURING PS122

MOSAIC, PS122, is an international project, coordinated by AWI and had the aim to investigate the coupled Arctic climate system for an entire year. The polar regions are important components of the global climate system, however the key Arctic climate processes are not well understood due to the lack of data. Therefore, measurements in the atmosphere, sea ice and ocean will take place, in addition the ecosystem and bio-geochemical processes will be investigated. Instruments will be installed on RV Polarstern and on the ice floe next to RV Polarstern and within a distributed network of autonomous stations within 60 nm around the main observatory.

The instrumentation on board of RV Polarstern and on the ice floe covered the following disciplines:

For the atmosphere: Measurements of physical, dynamical and chemical properties of the column of air above RV Polarstern from the surface to 35 km altitude including cloud and aerosol properties in the atmosphere. In-situ and remote sensing instruments at the ground were complemented by in-situ and remote sensing instruments on a small free flying research balloon similar to weather balloons, tethered balloons and Unmanned Airborne Vehicles (UAVs).

For sea ice and snow: Measurements of the physical, chemical and biological properties of sea ice and snow with in-situ and remote sensing instruments on the ice floe, a Remotely Operated under water Vehicle (ROV) and remote sensing instruments operated on helicopters. Measurements of ice mass balance, ice deformation, surface topography, and optical properties were made. Snow and ice samples were collected and analyzed in the laboratories on RV Polarstern and were brought back for analyses in land-based laboratories.

For the ocean: Measurements of the physical, chemical and biological properties of the water column below RV Polarstern from the surface to the sea floor. This includes water samples as well as collection of biological specimens using nets and water samples. Samples of ocean water and biological communities were analyzed in the laboratories on RV Polarstern and were brought back for analysis in land-based laboratories.

In addition, two Aircraft campaigns with POLAR 5 and POLAR 6 were closely coordinated with the RV Polarstern expedition PS122. the two campaigns were planned during spring and summer 2020. However, due to the worldwide travel restrictions due to the COVID-19 pandemic, the aircraft

campaign in spring 2020 was canceled. Therefore, the AWI aircrafts operated from Longyearbyen only in summer from August 29<sup>th</sup> to September 14<sup>th</sup> 2020.

#### GENERAL OPERATION METHODS

- In-situ and remote sensing of the physical, dynamical and chemical properties of the atmosphere and of the surface. with instrumentation on board of RV Polarstern, on the ice next to it, on free flying small research balloons, drones, on tethered balloons and on UAVs
- Collecting sea ice cores, hyperspectral sensors, electromagnetic ice thickness surveys (on ice and from helicopter), ice mass balance measurements, lidar surface topography, under-ice ROV (with side-scan sonar), sampling of sea ice and organic material for biological and chemical analyses (including nutrients and DNA)
- On-site measurements of structural and dynamical properties of the ice pack, by seismic and laser strain measurements, mechanical tests on ice cores and using high precision GPS units for ice motion at the floe and on surrounding floes
- Recording data by acoustic sonar devices (ADCP, AZFP and other doppler echo sounders).
- En route water pump and air collection devices to assess atmospheric physics, surface ocean physics, chemistry and plankton
- Physical measurements of the ocean vertical structure using Conductivity Temperature Depth (CTD) probes, turbulent shear probes, biooptical properties (spectral absorption, fluorescence of Coloured Dissolved Organic Matter, Chl a and Rhodamine; dissolved oxygen, methane and nitrate)
- <sup>222</sup>Rn as a proxy of sea-air gas fluxes - In order to measure <sup>222</sup>Rn continuously, a counter that specifically detects <sup>222</sup>Rn (RAD7) will be set up and continuously monitor <sup>222</sup>Rn from a flow-through cell for gas exchange, sampling from the ships intake seawater supply.
- CH<sub>4</sub>, N<sub>2</sub>O, CO and CO<sub>2</sub> in the atmospheric boundary layer and the surface water using a greenhouse gases underway observation system (Los Gatos N<sub>2</sub>O/CO-30-EP and GGA-34r-EP analysers and an integrated system, which can be programmed to take surface water sample and air sample for analysis in certain interval).
- Water samples for biological and chemical measurements, sampling of sea ice and organic material for biological and chemical analyses (including nutrients, volatiles compounds, and DNA)
- Ice-moored Sediment traps
- Water column profile for dissolved gases by submersible mass spectrometer.
- Video-optical recorders on the vessel, on and under the ice
- Operations of various plankton nets
- Fishing with long lines and fixed nets to collect a small number of species samples (no trawling activities)
- Environmental sensors (fluorescence, spectral light, echosounders)
- Endotherm observation (from ship and helicopter)

- Snow physical measurements: snow pits, surface laser scanning, snow sampling, tomography of structure of the snow pack. Optical properties and energy fluxes of sea ice and snow
- Sea ice mass balance by drilling, stakes, thermistor strings, surface EM and snow depth transects (Magna Probe). Ice internal stress and deformation studies
- Ground-truthing of snow and ice properties with remote-sensing instruments.

#### DATA MANAGEMENT AND AVAILABILITY OF DATA

To those scientists that are part of the MOSAiC Consortium the data will be available immediately after the cruise. In January 2023 the data will be publically available. The data are accessible via the data base PANGAEA. In addition, the data are published in the Reports of Polar Research by AWI and in other reports, papers and in international scientific journals and data bases.

The PANGAEA station lists can be found here:

PS122/3: <https://www.pangaea.de/expeditions/events/PS122%2F3>

PS122/4: <https://www.pangaea.de/expeditions/events/PS122%2F4>

PS122/5: <https://www.pangaea.de/expeditions/events/PS122%2F5>

During the MOSAiC expedition, buoys were used for measurements. Some of them are still active and provide data. A list of the buoys can be found here, including further information and real-time tracking: [https://data.meereisportal.de/gallery/index\\_new.php?lang=en\\_US&active-tab1=mosaic&active-tab2=buoymosaic](https://data.meereisportal.de/gallery/index_new.php?lang=en_US&active-tab1=mosaic&active-tab2=buoymosaic)

The additional requirements like the final cruise reports will be delivered to the Directorate of Fisheries by the end of 2022.