

Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute

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Abstract: POLARSTERN, operated by the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, is an ice going research and supply vessel. The main operation areas are the ice-covered seas of the northern and southern polar regions. The ship provides ideal working conditions for almost all disciplines of marine sciences, atmospheric and glaciological research. It can break ice up to 2m continuously and can operate up to 90 days at sea. POLARSTERN is therefore ideally suited for often long expeditions to remote polar regions. POLARSTERN regularly supplies the Antarctic research stations, especially the Neumayer Station III and the Kohnen Station (Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, 2016a). In the last 35 years POLARSTERN was in average 310 days per year at sea, she is the major research tool of the German polar research programme.

1 Introduction

RV Polarstern is a research and supply vessel that was commissioned in 1982. It is owned by the German Federal Ministry for Education and Research and is operated by the Alfred-Wegener-Institut. The private shipping company F. Laeisz is responsible for the professional management of the ship. Its home

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port is Bremerhaven. The ship is designed for operation in polar waters even during wintertime, and is currently one of the top polar research vessels worldwide, combining good icebreaking properties with a wide range of research capacities. RV Polarstern is equipped for multidisciplinary use and meets the demands of research in biology, geology, geophysics, glaciology, chemistry, oceanography, and meteorology. It has nine scientific laboratories. Additional laboratory containers can be stowed both on and below deck. Cold storage rooms and aquarium containers make it possible to conduct experiments on board as well as transport of samples and living marine organisms. Extensive hoisting equipment, such as cranes and winches, is available for the deployment of sampling devices. RV Polarstern is equipped with hydroacoustic echo sounders that can be used to conduct measurements at water depths of up to 10,000 meters and up to 150 meters into the seafloor. It is at sea for an average of 310 days per year. In addition to scientific expeditions, RV Polarstern is part of an international programme to supply the research stations in the Antarctic, making it the most important tool for the supply of the German Neumayer Station III and field research activities. Supply trips are always combined with scientific programmes.



Figure 1: Polarstern working in polar regions. Photo: AWI.

2 Technical data and capacities for work in polar regions

RV Polarstern is a double-hulled icebreaker that is able to operate in polar regions during the winter months, at temperatures less than -50°C . The ship is powered by four main engines and two variable-pitch propellers. Ice thicknesses of up to 1.5 m can be broken at a speed of about 5 knots, while thicker ice is broken by ramming. Table 1 gives an overview of the ship's technical data and capabilities for navigation in ice.

RV Polarstern is equipped with two helicopters (BK117 C-1). They are used for support in cases of emergency, to transport equipment and persons, are used as flying measuring platforms (for ice thickness measurements, for example), and facilitate navigation in ice by finding the fastest and most energy-efficient routes through the sea ice.

The on-board weather station is continuously staffed with a meteorologist and meteorological technician from Deutscher Wetterdienst, and is able to provide weather forecasts for safe ship and flight operations as well as for the daily expedition planning, even in remote regions. High resolution satellite maps for ice forecasting are obtained on land and stored in an information system used for science and



Figure 2: Polarstern Helicopter BK 117 - C1. Photo: AWI / M. Steffens.



Figure 3: Polarstern during the winter experiment in the Weddell Sea (Antarctica). Photo: AWI / S. Hendricks.

TECHNICAL DATA	
Length overall	118 m
Length between perpendiculars	108.77 m
Breadth max	25 m
Draught max	11.21 m
Displacement max	17277 t
Power (4 main engines)	14116 KW
Max. speed in open water	14.0 kn
Max. distance	ca. 18 000 nm
Max days on sea	75 days
Average operation time on sea per year	310 days
ICEBREAKER CAPABILITIES	
Classification (Germanischer Lloyd)	GL +100 A5 Arc 3 / GL+MC ARC 3 Aut
Minimal working temperature	-50°C
Cruising speed in ice thickness <1.5m	5 kn
Operation in ice thickness >1.5m	Ramming
SPEED FOR EXPEDITION PLANNING	
Cruising speed in open water	10.5 kn
Cruising speed in 1/10 - 2/10 ice covering	7.0 kn
Cruising speed in 3/10 - 6/10 ice covering	5.0 kn
Cruising speed >6/10 ice covering	2.0 kn
PERSONNEL	
Crew	43 / 44 (incl. 1 doctor / 1 nurse)
Weather station	1 meteorologist / 1 weather technician
Helicopter crew	2 pilots / 2 technicians
Scientific personnel	49 / 47
HELICOPTER	
BK - 117 C-1	2x
Max range	250 nm
Max takeoff weight	3350 kg
Max load	800 kg
Max sling load	1200 kg
Cruising speed	130 kn
Max pax	7

Table 1: Technical details.

navigation. RV Polarstern has a well-equipped surgery room and hospital staffed by a physician and a nurse that proper medical treatment is ensured even in remote areas.

3 Research capacities

RV Polarstern has a variety of winches and cables, hoisting equipment, laboratories, and laboratory container spaces. Since RV Polarstern was designed to be a ship that can be used to serve as many scientific disciplines as possible, the labs, containers, and winch configurations are customised and reorganised according to the needs of the various research groups before an expedition begins.

CRANES	
Crane - foreship	25 t
Crane - astern - starboard side	15 t
Crane - astern -port side	5 t
Slide beam - starboard side	20 t
Slide beam - starboard side	5 t
Stern A-frame	30 t
WINCHES AND CABLES	
2 x Trawling cable for fisheries (30 mm)	3000 m
1 x Geo wire (18 mm)	8000 m
2 x Fibre optic cable (18 mm)	8000 m
1 x Coax cable (11 mm)	4000 m
2 x Coax cable (11 mm)	7000 m
1 x Dyneema (11 mm)	6000 m
1 x Dyneema (6 mm)	3000 m
LABORATORIES	
Meteorological laboratory	1
Wet labs	3
Dry labs	6
Chemistry lab	1
Hydroacoustic lab	1
Scientific cool stores (+4°C - 24°C)	3
Additional place for:	
Temperature controlled lab containers	5
Radioisotope container	1
Working and special lab containers	div. below and on deck

Table 2: Infrastructure for scientific work on board.

The permanently installed sensors and instruments on board RV Polarstern are summarised in Table 3. In addition to the instruments required for standard meteorological observations, a range of instruments for measuring water parameters (temperature, salinity, pCO₂, nutrients, etc.) are in constant operation and made available to researchers as en route data. Hydroacoustic devices for recording



seafloor topography and sediment characteristics, as well as instruments for measurements in the water column are also available. For positioning of devices underwater (ROV, AUV, moorings, etc.), a POSIDONIA system is permanently installed. An additional mobile GAPS system is also available. All incoming data from sensors and instruments, from the weather station, from navigational instruments (ship speed, course, roll and pitch motions, etc.), and ship equipment (e.g. winch parameters) are recorded and stored in a central data logging system (DShip 3) and are available to researchers in each lab and via WLAN in real time. After the expedition, a copy of the data is stored at the Alfred-Wegener-Institut and kept available to scientists even years after an expedition.

METEOROLOGICAL LABORATORY	
All relevant sensors for weather forecast	
Regular weather balloon samplings / radiosonde	
Neutron monitor, Myon detector	
DEVICES FOR WATER MEASUREMENTS	
Thermohalinograph (Wassertemperature/salinity)	SEABIRD SBE 21/38
pCO2 sensor	General Oceanic / SubCtech
Ferrybox	4H-Jena
HYDRO ACOUSTIC DEVICES	
Acoustic Doppler Current Profiler (ADCP)	150 kHz
Multibeam Hydrosweep DS3	13.6 - 16.4 kHz
Sediment Echo Sounder Parasound P70	19 - 38 kHz / 0.5 - 6.0 kHz
Multifrequency Echo Sounder EK60/80	18, 38, 70, 120, 200 kHz
Underwater Position System (POSIDONIA)	8 - 16 kHz
Underwater Position System (GAPS)	22 - 30 kHz
GEOPHYSICAL INSTRUMENTS	
Gravity meter	Bodensee Gravimeter Geosystem (BGGS)
Magnetometer	Magson GmbH
High-performance compressor for seismic	210 bar, 516 l/sec, 550 KW
DATA MANAGEMENT SYSTEM	
DShip version 3	WERUM

Table 3: Scientific devices and data management systems installed on board Polarstern.

Large equipment such as work-class sized ROVs and the MeBo submarine drilling device (MARUM, University of Bremen) are also operated on board RV Polarstern. The infrastructure of this equipment is easily integrated into the ship's infrastructure that large scientific equipment can also be used in ice-covered regions at high latitudes.

4 Applications, use, and access to the infrastructure

RV Polarstern operates in the southern and northern polar regions (Figure 4) and during the last 35 years she has been at sea for an average of 310 days per year. In the Antarctic, the ship's activities have been focused on the Weddell Sea, the Antarctic Peninsula, the Scotia Sea, and the Drake Passage. In the Arctic, work is focused on the Fram Strait, areas off the east coast of Greenland, and the central Arctic Ocean. RV Polarstern is also able to operate in difficult high latitude regions, and has several times been operating at the North Pole. Two winter experiments in the Antarctic have shown that the ship can also be used at very low temperatures (below -50°C , Figure 3) and under difficult ice conditions. During the necessary transit cruises from north to south and back, en route measurements are continued, and the resulting data is made available to science. The scientific programmes during transit cruises are focused primarily on investigations of the atmosphere and on ocean-atmosphere exchange processes. In recent years, transit cruises have been increasingly used for student training.

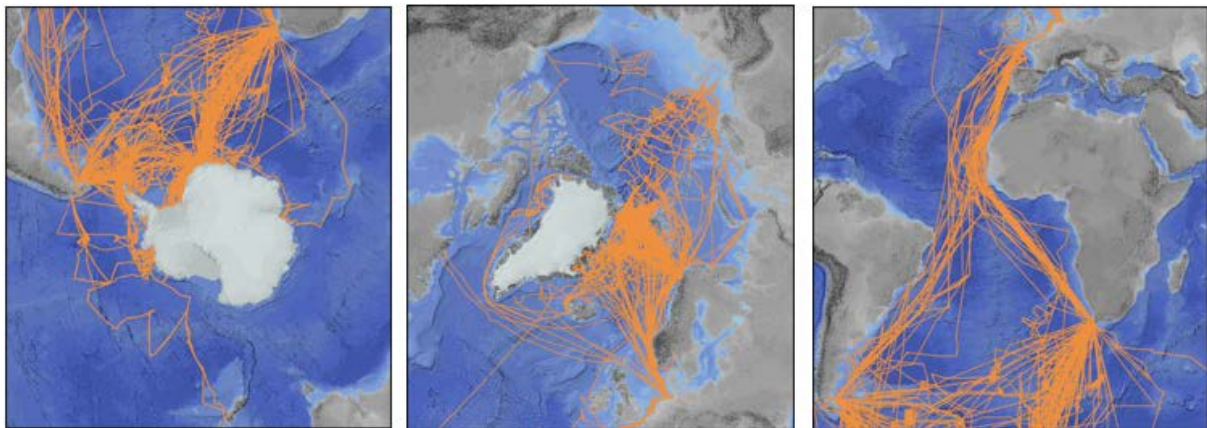


Figure 4: Operation areas in the Antarctic, Arctic and the Atlantic transfer routes.

RV Polarstern plays an important role both in Germany and internationally to enable access to the polar marine areas. On average, around 30% of the expedition participants come from international partner institutes and around 25% come from domestic institutes and universities outside the Helmholtz Association of German Research Centres. Participation is based on joint scientific programmes and by secondary users (smaller university research teams, for example). Ship time is granted through a review process that is shared for all large and medium-sized German research vessels. Information on deadlines and the review process is available from a common web portal, which is also used for the submission of applications:

<https://www.portal-forschungsschiffe.de> (in German and English).

5 RV Polarstern as a supply vessel

RV Polarstern is part of an international supply network for Antarctic research stations. The primary partners in this network are Great Britain and South Africa. Without the good icebreaking capacities of RV Polarstern, the regular supply of Neumayer Station III (Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, 2016a) and field expeditions would not be possible. Around 80 spaces for 20' containers are available on board, which can be stowed both on the foredeck and the front cargo hold. Without helicopter operations, other loading options are available on the helideck. RV Polarstern has additional bunker capacity allowing storage of fuel for stations, vehicle fleets, and flight operations, for example for the research aircraft Polar 5 and 6 (Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, 2016b), as well as for international partners.

Supply and waste disposal for Neumayer Station III takes place at the Atka Iceport, directly on the edge of the ice shelf (Figure 5) in Atka Bay. Both cranes (on the fore and aft parts of the deck, respectively) are used for loading and unloading. Bunker is handed over from the ship to tank containers on the ice edge.



Figure 5: Polarstern in the Atka Bay, Weddell Sea, Antarctica supplying Neumayer Station III. Photo: AWI / H. Grobe .

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