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HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS96

Polarstern

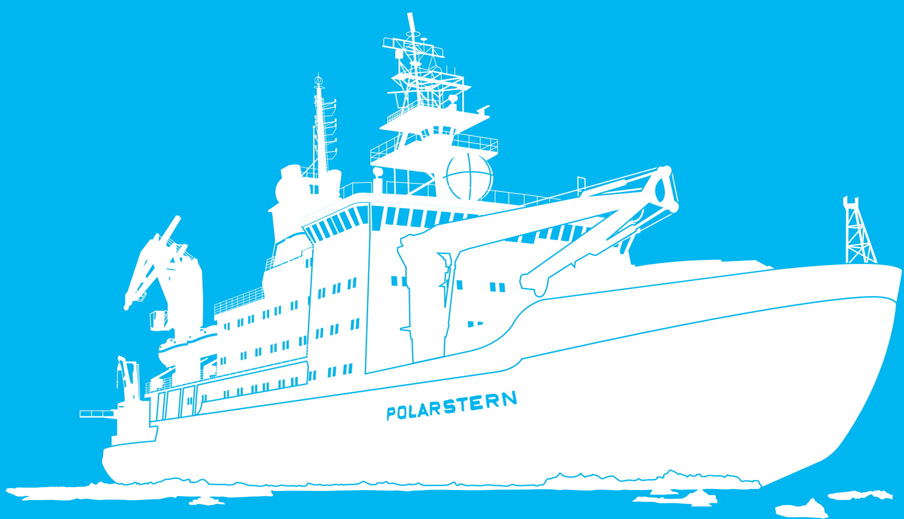
PS96

Cape Town - Punta Arenas

06 December 2015 - 14 February 2016

Coordinator: Rainer Knust

Chief Scientist: Michael Schröder



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FROSN - ANT XXXI/2

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FROSN: Filchner-Ronne Outflow System Now

Coordinator
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1. ÜBERBLICK UND FAHRTVERLAUF

Michael Schröder (AWI)

Der Fahrtabschnitt PS96 FROSN, Filchner Ronne Outflow System Now (ANT-XXXI/2,)wird am 06. Dezember 2015 in Kapstadt (Südafrika) beginnen und am 14. Februar 2016 in Punta Arenas enden. *Polarstern* wird direkt die eisbedeckte Atka-Bucht anlaufen, um die *Neumayer-III-Station* zu versorgen. Bedingt durch eine Vielzahl von Feldkampagnen im Hinterland von *Neumayer* ist das Frachtaufkommen und die Treibstoffmenge maximal, so dass für die Versorgung die doppelte Zeit eingerechnet werden muss. An *Neumayer* wird auch das vierköpfige Warmblüterteam an Bord gehen, was im Drescher-Inlet eine mehrwöchige Station betreiben wird. Der Gütertransport erfolgt mit *Polarstern.* Wenn die Eissituation es erlaubt, wird im Gebiet Austasen ein eintägiges Messprogramm eingeschoben, was eine weitere Überprüfung des BENDEX Experiments (Benthos-Störungsexperiment aus dem Jahr 2003/2004) ermöglichen soll. Nach dem Aufbau des Drescher-Camps wird *Polarstern* sich in das eigentliche Forschungsgebiet, dem weiten Schelf vor dem Filchner-Ronne Schelfeis begeben, um die bereits im Jahre 2013-2014 (FOS, Filchner Outflow System, PS82 (ANT XXIX/9) begonnenen ozeanographischen und biologischen Untersuchungen fortzuführen und zu ergänzen (Abb. 1 und 2).

Dieses Meeresgebiet ist besonders im Nordteil des Filchner Grabens geprägt durch die Interaktion von sehr kaltem Eisschelfwasser (ISW, Ice Shelf Water) aus dem Süden mit dem warmen Tiefenwasser (WDW, Warm Deep Water) des Weddellmeeres. Durch diese Vermischung werden sowohl die Tiefen- (WSDW, Weddell Sea Deep Water) als auch Bodenwassertypen (WSBW, Weddell Sea Bottom Water) des Weddell Meeres gebildet, die für die globale Ozeanzirkulation und die Belüftung des tiefen Ozeans von großer Bedeutung sind.

Diese hydrographischen Besonderheiten am Kontinentalabhang des Weddellmeeres sind sehr wahrscheinlich auch die primäre Ursache für die erhöhten biologische Aktivitäten in diesem Gebiet.

Die Bildung von Tiefen- und Bodenwasser (WSDW/WSBW) im südlichen Weddellmeer ist sowohl qualitativ als auch quantitativ stark durch die Produktionsvorgänge von Schelfeiswasser (ISW) unter dem Filchner-Ronne Schelfeis beeinflusst. Eigene hydrographische Messungen mit *Polarstern* im Jahr 1995 entlang der Filchner-Schelfeisfront zeigen, dass der Abbruch von drei sehr großen Eisbergen im Jahr 1986 und deren Gründung auf der flachen Berkner Bank, die Zirkulation und die Wassermassenbildung im Filchner-Trog signifikant modifiziert haben. Auch die angrenzenden Seegebiete zeigen deutliche Veränderungen in den Wassermassencharakteristika und Strömungsmustern im Vergleich zu Messungen aus den frühen 1980er Jahren. Neuere Messungen aus der Sommersaison 2013-2014 (PS82) ergeben ein neues Bild, das den Ausstrom von ISW am Osthang des Filchner-Grabens zeigt. Modellszenarien mit dem finiten Elemente Modell FESOM zeigen, dass klimabedingte Veränderungen des Küstenstroms zu einem erhöhten Zufluss von warmem Wasser (Modified Warm Deep Water - MWDW) ab Mitte des einundzwanzigsten Jahrhunderts in dieses Gebiet führen werden. Diese Veränderungen betreffen zunächst den Filchner-Graben und beeinflussen dann die Zirkulation unter dem Filchner-Ronne Schelfeis. Die Folge davon sind höhere Abschmelzraten des Schelfeises. Eine höhere Schelfeisdynamik mit häufigeren Eisbergstrandungen und eine Erhöhung der Wassertemperatur werden erheblichen Einfluss auf die Artenvielfalt des südlichen

Weddellmeeres haben. Deshalb ist die Messung der Ist-Situation in diesem Gebiet so wichtig, auch um eventuell zukünftige Veränderungen der Wassermassen einordnen zu können.

Ergänzend zu den Messungen auf dem Schiff findet eine internationale Bohrkampagne (BAS, AWI und Norwegen) auf dem Filchner-Schelfeis statt, die in den Jahren 2015 bis 2017 an 4 Lokationen das Schelfeis durchbohrt, um Messgeräte in der Wassersäule unter dem 400 m bis 1.200 m dicken Schelfeis zu verankern. Dazu ist es nötig, dass *Polarstern* wissenschaftliches Equipment und Versorgungsgüter an einem Depot an der Kante des Ronne-Schelfeises abgibt, damit die Bohrungen in der Saison 2016-2017 stattfinden können. Sollte dieses Depot infolge zu starker Meereisbedingungen nicht erreicht werden, ist eine alternative Abgabe der Güter an der britischen Station Halley geplant. (siehe auch Abb. 2)

Die wichtigsten Forschungsziele der Expedition PS96 FROSN (ANT XXXI/2) sind:

1. Charakterisierung der hydrodynamischen Prozesse und Wassermassen im Filchner-Ausfluss-System (Filchner Outflow System). Dabei soll die Rolle der Meeresbodentopographie für die Wassermassenzirkulation ebenso erfasst werden, wie die Raten von Tiefen- und Bodenwasserbildung unter Einbeziehung der Schmelzraten des Schelfeises. Es sind hier weitere Stationen im West- und Südteil des Filchner-Grabens geplant, die die Messungen von PS82 ergänzen
2. Eine Abschätzung von möglichen Veränderungen dieser hydrographischen Prozesse durch rezente Veränderungen des antarktischen Klimas.
3. Untersuchungen zur biologischen Produktion im Filchner-Ausflusssystem und zu den Energieumsatzraten im trophischen Nahrungsnetz.
4. Eine Abschätzung des Einflusses von möglichen Veränderungen hydrographischer Gegebenheiten und der Schelfeisdynamik auf die Biodiversität und die Ökosystemfunktionen im Filchnergebiet.

Das wissenschaftliche Hauptprogramm wird im Meeresgebiet vor dem Filchner-Ronne-Schelfeis durchgeführt. Sollten die Eisverhältnisse ein Eindringen in dieses Gebiet nicht erlauben, wird ein Alternativgebiet nördlich davon untersucht. Ein intensives CTD-Programm wird die hydrographischen Parameter aufnehmen und Wasserproben sammeln, um die unterschiedlichen Wassermassen zu identifizieren. Das geplante Stationsgebiet ist der gesamte westliche Teil des Filchner-Grabens sowie die Schelfgebiete vor dem Filchner-Ronne Schelfeis (Abb. 2) in Abhängigkeit der Meereissituation. Drei Langzeit-Verankerungen sollen im Gebiet von 76° S geborgen und wieder ausgebracht werden, ergänzt durch eine Kurzzeitverankerung während der Untersuchungszeit. Dazu kommt der Austausch zweier norwegischer Verankerungen in der Filchner-Schwelle. Die Meeresbodentopographie und Sedimentcharakteristika werden mit Hilfe des Fächersonars DS-III und mit Hilfe von Parasound untersucht. Um die Rolle des Meereises für die biologischen Prozesse zu untersuchen, sollen Meereisproben gewonnen und bio-optische Messmethoden direkt auf dem Eis angewendet werden. Zur Bestimmung der Massen- und Energiebilanz des Meereises werden in enger Kooperation mit den Meereisphysikern Bojen mit autonomen Messlaboratorien auf dem Eis ausgebracht und Eisbeobachtung entlang der Fahrtroute durchgeführt.

Die biologischen Untersuchungen beinhalten Wasserproben und Planktonfänge zur Bestimmung der Primärproduktion, der Verteilung von Planktonorganismen und deren Biomasse. Produktionsraten des Zooplanktons sollen anhand von Laborexperimenten an Bord bestimmt werden. Die Verteilung und Biomasse pelagischer Fische wird mit Hilfe von Netzfängen ermittelt. Die Bestimmung der Verteilung und des Vorkommens von Benthosarten und demersalen Fischen, sowie die Bestimmung ihrer Biomasse wird durch videogeführte Bodengreifer, Multicorer, Agassiz Trawls und mit Hilfe von Grundschleppnetzfängen durchgeführt. Zur Ermittlung der räumlichen Verteilung werden auch HD Video Transekte mit einem Unterwasserfahrzeug (ROV) durchgeführt. Daten zu Produktionsraten des Benthos und der Fische werden mit Hilfe der Biomassedaten anhand standardisierter Rechenverfahren bestimmt und durch Laborexperimente an Bord und in den Heimatlaboratorien unterstützt.

Die Bentho-pelagischen-Kopplungsprozesse sollen durch Kurzzeitverankerungen erfasst werden, die mit Strömungsmessern und Sedimentfallen bestückt sind. Ergänzt werden diese Messungen durch *in-situ* Experimente, die mit dem ROV durchgeführt werden und durch biochemische Messungen des Sediments und der gelösten organischen Substanzen (dissolved organic matter - DOM). Proben zur Untersuchung des Nahrungsnetzes (Stabile Isotope, Mageninhaltsuntersuchungen), der Bioenergetik, der Ökophysiologie und zur Genetik werden von ausgewählten Organismen gewonnen, um später im Labor gemessen zu werden. Des Weiteren sollen lebende Tiere gefangen werden, um für Laborexperimente an Bord oder zum Transport nach Bremerhaven zur Verfügung zu stehen.

SUMMARY AND ITINERARY

The cruise leg PS96 FROSN, Filchner Ronne Outflow System (ANT XXXI/2) will start on 6th December 2015 in Cape Town and will end on 6th February 2016 in Punta Arenas. *Polarstern* will sail directly to the ice covered Atka Bay to supply the German station *Neumayer III*. Due to an extended land - field- ????programme in the back-country of the station, the logistic requirements are at the limits for the ship so that the length of stay near *Neumayer* will be longer than normal. At *Neumayer* the seal-team (4 scientists) will join us. They will build up a 4-weeks camp in the Drescher Inlet. *Polarstern* will be taking all their equipment to the inlet. If the sea-ice situation allows a one day stay at Austasen, the benthologiosts, would continue the Bendex experiments that had been started in 2003/2004. After the built up of the Drescher camp *Polarstern* will adjourn to its main scientific region, the vast shelf areas in front of the Filchner-Ronne iceshelf. Here an extensive oceanographic and biological programme will proceed and complete the station grid, which already started during the FOS campaign (Filchner Outflow System) in 2013/2014 on the ANT XXIX/9, PS82 expedition (Figs. 1 and 2).

The marine vicinities of the Filchner Ice Shelf have been identified as a special area in the southern Weddell Sea, where the outflow of Ice Shelf Water (ISW) of the Filchner Ronne Ice Shelf interacts with warmer deep water of the Weddell Gyre. The region is a key area for the formation of Weddell Sea Deep and Bottom Water (WSDW and WSBW) and therefore of major importance for the global ocean circulation. These hydrographical features are supposed to be the primary cause converting this region into a biological "hotspot" indicated by recent investigations. Previous investigations from the 1980's tell us that the region is characterized by high abundances of different warm blooded species and a higher production in the pelagic system as compared to other regions of the Weddell Sea. This holds especially true for the Antarctic silverfish with its high biomass and production values, which is an important food source for marine mammals in the upper food web.

The formation of deep and bottom water (WSDW/WSBW) in the southern Weddell Sea is strongly influenced by flow of Ice Shelf Water (ISW) out of the Filchner-Ronne

Ice cavity. Own hydrographic measurements along the Filchner Ice Front carried out with *Polarstern* in 1995, show that the breakout of three giant icebergs in 1986 and their grounding on the shallow Berkner Bank still modified the circulation and water mass formation in the Filchner Trough. Even the adjacent sea areas show significant changes in the water mass characteristics and flow patterns compared to measurements from the early 1980s. A recent model scenario indicates that a redirection of the coastal current into the Filchner Trough and underneath the Filchner-Ronne Ice Shelf during the twenty-first century would lead to increased inflow of warm MWDW waters (Modified Warm Deep Water) into the deep southern ice-shelf cavity accompanied by a water temperature increase of more than 2°C, with the consequence of higher melting rates of the shelf-ice, a higher shelf ice dynamic and a higher habitat water temperature. A higher shelf ice dynamic with higher numbers of iceberg scouring events and an increase in water temperature will significantly influence the biodiversity of the southern Weddell Sea.

As an add-on to the scientific ship's programme an international drilling programme (BAS, AWI and Norway) will start on the Filchner ice stream to drill 4 holes through the 400 m-1,200 m thick ice shelf in the summer seasons 2015 to 2017. At each location scientific instruments should be lowered into the cavity underneath the shelf ice to measure a variety of physical parameter in the water column. Therefore *Polarstern* has to bring scientific and logistic equipment to a depot near the edge of the Ronne ice shelf. If sea-ice conditions do not allow the deloading at the Ronne depot, everything will have to be carried to the British Halley Station (see also Fig. 2).

The main objectives of the PS96 (FROSN) expedition are:

1. To characterize the hydrographical features and water masses of the Filchner Outflow System (FOS), the role of bathymetry for current patterns, and the deep and bottom water formation rates with the related basal melting rates. More stations in the western and southern part of the Filchner Trough are planned to supplement the measurements of PS82.
2. To estimate possible changes in these hydrographical features induced by observed change in Antarctic climate.
3. To investigate the high productive Filchner Outflow System as a biological "hotspot", producing a high-energy turnover to subsequent trophic levels up to the seals as top predators of the food web.
4. To estimate the impact of possible changes in the hydrography and increasing shelf and sea ice dynamics on the biodiversity and ecosystem functioning of the southern Weddell Sea.

The main scientific programme will be performed in the area of the Filchner Ronne shelf area. If the ice conditions do not allow to enter the Filchner region, an alternative research area in the north will be investigated. An intensive CTD programme is planned to record hydrographical parameters and to get water samples to identify the different water masses. The main research area is the western part of the Filchner Trough as well the area in front of the Filchner Ronne Ice Shelf (Fig. 2) depending on ice condition. Three long-time moorings will be recovered and re-deployed along 76° S together with one additional short-term mooring for the biologists. The replacement of two Norwegian moorings in the Filchner sill is also planned. The sea floor topography and sediment characteristics will be investigated with a multi-beam system (DS-III) and parasound. To investigate the role of sea ice for the biological processes, ice cores will be taken and bio-optical measurements in the ice will be conducted. In close cooperation with the icephysicists the mass- and energy balance of sea ice will be measured by deploying autonomous observatories (ice buoys) and continuous along-track sea ice observations.

The biological investigations will include water samples and plankton catches to estimate primary production, plankton species distribution and biomass. Zooplankton production rates will be measured in laboratory experiments on board. Distribution and biomass of pelagic fish fauna will be estimated by pelagic fishing trawls. Species distribution and biomass of benthic invertebrates and demersal fishes will be measured by video guided grab samples, multi- corer, Agassiz trawls, bottom trawls, and HD video and photo transects operated with a ROV-system (Remotely Operated Vehicle). Data on production rates of benthos and fishes will be estimated by standardized calculation methods supported by additional laboratory measurements and experiments on board and in the home laboratories.

Bentho-pelagic-coupling processes will be studied by a short term mooring equipped with a sediment trap, by additional *in-situ* experiments with the ROV, and by biochemical and molecular analyses of sediments and dissolved organic matter (DOM). Samples for the investigation of food web properties (stable isotopes, gut content), bioenergetics, eco- physiology and genetics will be taken from selected species. Live organisms for on board experiments will be caught and live animals will be transported to Bremerhaven for ecophysiological experiments at the home laboratories.

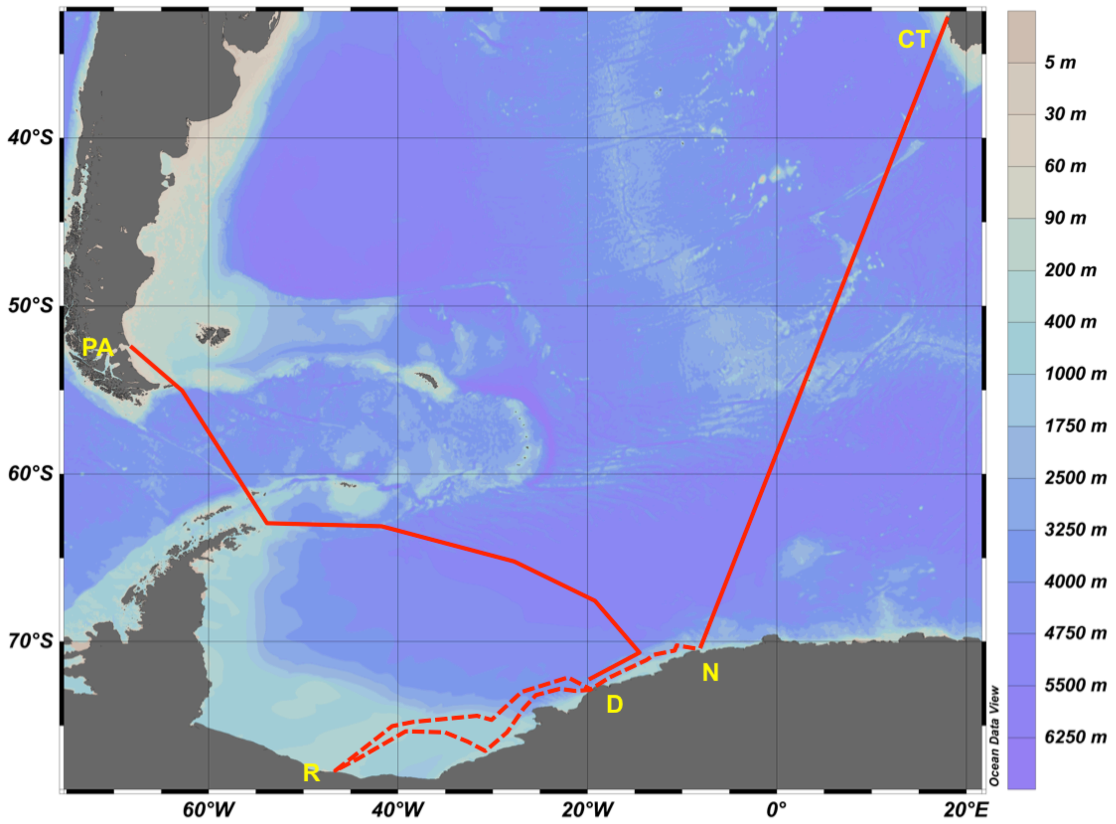

Abb. 1: Geplanter Fahrtverlauf PS96 mit den Abkürzungen CT= Cape Town, N= Neumayer, D= Drescher, R= Ronne Depot und PA= Punta Arenas

Fig. 1: Planned route PS96 with the abbreviations CT= Cape Town, N= Neumayer, D= Drescher, R= Ronne Depot and PA= Punta Arenas

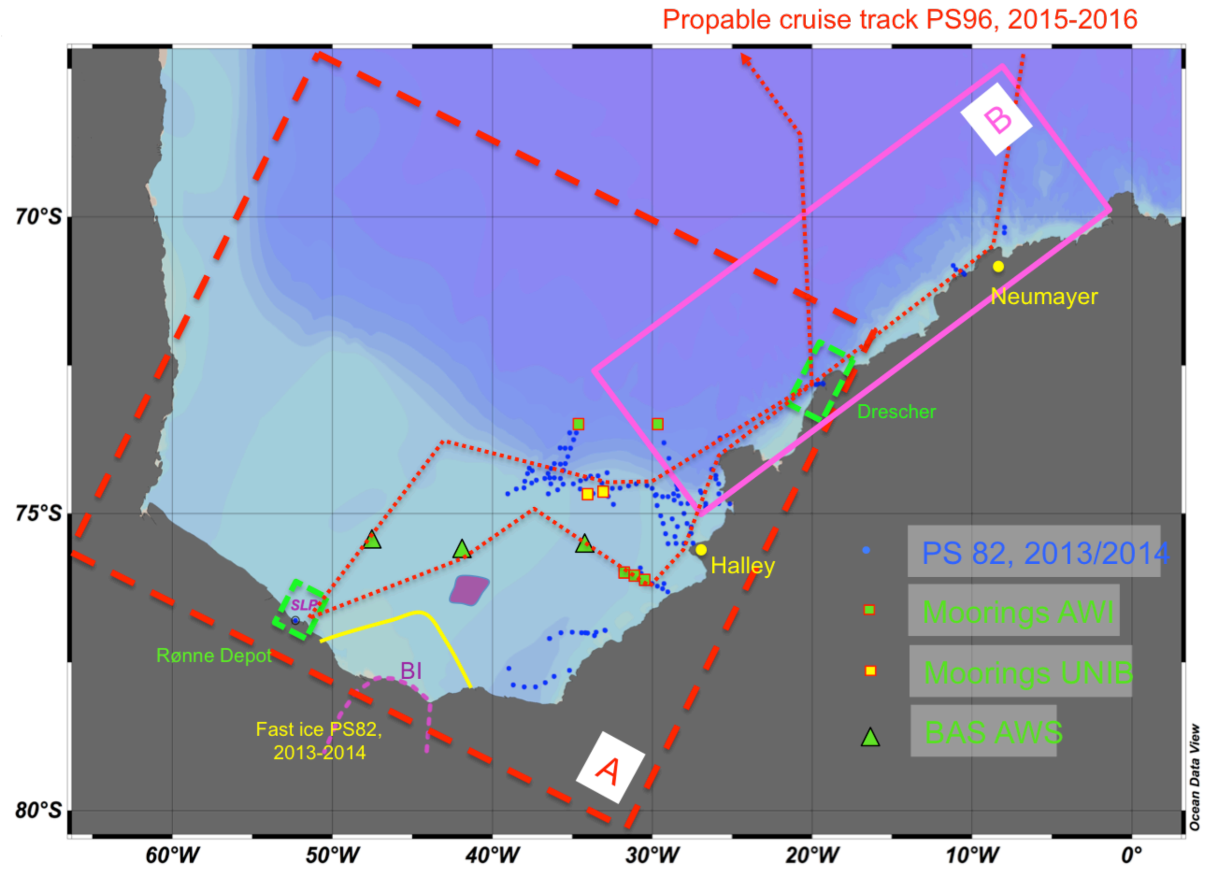

Abb. 2: Haupt-Untersuchungsgebiet sowie Alternativgebiet mit geplantem Fahrtverlauf PS96. Es sind außerdem die Stationen der Fahrt PS82 (blaue Punkte) angegeben sowie die Verankerungspositionen (grüne und gelbe Quadrate). Außerdem werden 3 automatische Wetterstationen des BAS ausgesetzt (grüne Dreiecke). Zusätzlich ist der Festeisbereich der Saison 2013/2014 (gelbe Linie) und die Position des Eisbergs A23a (pink) angegeben.

Fig. 2: Main research area as well as alternative area of the planned route PS96. The stations of the voyage are also indicated (blue dots) as well as the mooring positions (green and yellow squares). Furthermore 3 automatic weather stations of the BAS will be deployed (green triangles). In addition the landfast ice of the season 2013/2014 (yellow line) and the position of the iceberg A23a (pink) are shown.

2. OCEANOGRAPHIC, METEOROLOGIC, AND GEOLOGIC INVESTIGATIONS

2.1 Oceanography and sea ice

2.1.1 Hydrographic conditions and distribution of oceanic trace gases off Filchner-Ronne Ice Shelf, southern Weddell Sea

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Objectives and methods

The Filchner Trough in the southeastern Weddell Sea is considered to be the main conduit for Ice Shelf Water (ISW), defined by temperatures below the surface freezing point. ISW carries the glacial meltwater from underneath the Filchner-Ronne Ice Shelf towards the continental slope. Here, mixing with open ocean waters forms the deep and bottom waters of the Weddell Sea, the former being the precursor of Antarctic Bottom Water and thus one of the main contributors to the ventilation of the global abyss. Today, only traces of warm water of open ocean origin, called modified Warm Deep Water (mWDW), sporadically flow along the eastern slope of the trough towards the ice shelf front. However, projections based on the output of our coupled sea ice–ocean-ice shelf models indicate that in the near future the trough might also become the main route for Warm Deep Water (WDW) into the deep Filchner-Ronne Ice Shelf (FRIS) cavity. The penetration of undiluted WDW underneath FRIS, similar to the smaller ice shelves fringing the Amundsen Sea to date, is bound to cause a dramatic increase in basal melting. The latter changes ice shelf thickness, reduces the buttressing effect of bottom topography and ultimately influences the dynamics of the ice streams draining the West and East Antarctic Ice Sheets. The resulting freshwater input will have a profound impact on the structure of the shelf water column, the sea ice cover, and the formation rate of deep and bottom waters.

This expedition is closely linked to oceanographic/glaciological field work on the Filchner Ice Shelf, designed to (a) extend existing data sets, necessary for modeling the coupled ice shelf - ice sheet dynamics, and (b) build-up a reference data set for the expected changes within the ice shelf/sheet system due to a warming ocean.

General objectives:

- Specify the physical properties controlling the Filchner Trough in/outflow.
- Determine the temporal variability of the hydrography and tracer distribution in the Filchner Trough with regard to Ice Shelf Water outflow, Antarctic Bottom Water formation, and modified Warm Deep Water inflow.
- Identify temporal trends.
- Provide a comprehensive dataset for numerical model validation and initialisation of coupled ocean-ice shelf - ice sheet models.

Specific objectives:

- Determine the course of the coastal current in the south eastern Weddell Sea and mWDW flowing towards the Filchner Ice Shelf front.
- Specify the path of HSSW from the Berkner Shelf into the Filchner Trough.

- Produce an improved estimate of glacial melt water inventories and basal melt rates for the southern Weddell Sea (Filchner Ice Shelf) to deduce temporal trends in the future

The combination of CTD casts from aboard *Polarstern* and its helicopters together with long-term moorings in the Filchner Trough and underneath the Filchner Ice Shelf aims to describe the present physical environment in the southeastern Weddell Sea, and to monitor its variability and the changes which might occur. Tracer observations will help to quantify

- ice shelf basal melting (stable noble gas isotopes [3He, 4He, Ne] are used to determine basal glacial melt water inventories),
- Antarctic Bottom Water formation (transient trace gases [CFCs] to identify transit time scales and formation rates), and
- the variability of both compared to observations from previous expeditions, e.g., PS92 (ANT 29-9), 2013-2014.

Work at sea

After transit to the target area, measurements will be carried out with the CTD/water bottle system to acquire hydrographic data and water samples as outlined in Fig. 2 . A minimum of 320 ship-based CTD-casts, and another 20 helicopter-based CTD casts are planned to survey the area. From the full-depth profiling casts we intend to obtain about 600 water samples for noble gas isotopes and about 1,200 water samples for CFCs analyses. Since the water sample capability of the helicopter-deployed CTD system is limited, we will only take 2-3 samples from near the bottom and the surface at these sites. For the purpose of our objectives it is necessary to have stations/transects (1) close to the Filchner Ice Shelf front, (2) parallel and normal to the Filchner Trough axis, and (3) along the down-slope path of outflowing ISW/WSBW. The total station time of this proposal amounts to 14 days (Fig. **2**; helicopter operations are not assumed to consume relevant ship time). In cooperation with the Bjerknes Centre in Bergen, Norway, it is planed to deploy three additional moorings, aimed to measure both the southward flowing mWDW and the northward flowing ISW on the eastern flank of the Filchner Trough (yellow squares in Fig. **2**). These moorings will provide the seasonal variation of both water masses over a time span of 2 to 8 years.

The water samples for helium isotopes and neon will be stored in 50 ml gas tight copper tubes, which will be clamped of at both sides. The noble gas samples are to be analyzed at the IUP Bremen noble gas mass spectrometry lab. Water samples for CFC measurements will be stored in 100 ml glass ampoules and will be sealed off after a CFC-free headspace of pure nitrogen has been applied. The CFC samples will be later analyzed in the CFC-laboratory again at the IUP Bremen.

Data policy and storage

Soon after the end of the expedition, a final calibration of the hydrographic data will be done using standard procedures. The preparation of the helium/neon and CFC samples as well as the analysis and accurate quality control will be carried out in the labs of the IUP Bremen. Once published, all data sets will be transferred to data bases such as PANGAEA or send to the German Oceanographic Data Center (DOD), where they are available for the international scientific community. PANGAEA guaranties long term storage of the data in consistent formats and provides open access to data after publication.

2.1.2 Sea ice physics

S. Schwegmann (not on board, AWI), S. Arndt (AWI), L. Rossmann (AWI)

Objectives

Sea ice and snow are key elements in the global climate system. Through their manifold interactions with the atmosphere (e.g. the ice-albedo feedback) and the ocean (e.g., freshwater budgets during melt and formation) they have strong impacts on global circulation patterns (Brandon et al., 2010), which reach far beyond the polar regions. Moreover, sea ice serves as an important habitat for the marine ecosystem and plays an essential role for biogeochemical fluxes, as it highly alters the exchange between the atmosphere and the ocean (Vancoppenolle et al., 2013). Given the increasing role of remote sensing observations for sea ice research, snow cover properties become even more important, since they dominate most retrieval algorithms and data interpretation.

It has been found out that Antarctic sea ice and snow underlies changes that are regionally different. Mechanisms which might cause these regional changes have been discussed in literature (e.g., Holland and Kwok, 2012; Schwegmann et al., 2013), but are still not well understood and are not quantified sufficiently yet. In order to overcome this lack in understanding, comprehensive and consistent observations are needed during all seasons in different regions. It is necessary to describe the seasonal cycle and interannual and regional variability of key variables, in particular those of sea ice thickness, snow depth, and sea ice drift (ECVs). Since it is not possible to derive the missing process understanding from remote sensing data only, we need alternative methods. Valuable techniques for providing seasonal data are autonomous buoys, which measure the sea ice growth (ice mass balance buoys, IMB), the snow accumulation (snow depth buoys) and sea ice dynamics (drift and deformation, GPS buoys) over several months. Information from those buoys can then help to evaluate and improve remote sensing retrievals and numerical models and will enhance our understanding of the physical interactions between the ocean, sea ice, snow and the atmosphere.

Accordingly, InSIDe aims to investigate the mentioned ECVs and the deformation processes in the Weddell Sea by deployment of autonomous systems in the Filchner Outflow System, complementary to those deployments done during PS81 in austral summer 2013/14.

Work at sea

To address the major goal of InSIDe, IMBs and snow depths buoys will be complementary deployed during sea-ice stations. These buoys will measure and transmit physical snow and sea-ice properties and complement identical deployments in the Weddell Sea during PS81, PS82 and PS89. At two locations, radiation stations will be added to the buoy pairs in order to measure the optical properties which have an influence on the ice mass balance. The GPS buoys will be deployed as an array around the IMB, snow depth buoys and radiation station in order to relate dynamical processes and the temporal evolution of sea-ice and snow thickness. Some buoys will be deployed during sea-ice stations while the ship stops, other buoys will be deployed via helicopter transport. At the buoy sites, information about the initial sea-ice and snow conditions will be measured using different methods. In addition we plan to perform some short ice stations, generally via helicopter transport, in order to study sea ice and snow properties in the vicinity of the deployed buoys. This will help us to evaluate the representativeness of our buoy data.

Complementary information on the physical state of the sea ice including its concentration, the three most dominant ice classes and their respective coverage as well as ice floe structure and snow thickness will also be visually detected hourly from the bridge of RV *Polarstern* between ice stations. Data will be documented together with the meteorological state and the location within a standardized protocol for such observations. Those data will contribute to the international data base of the SCAR-endorsed ASPeCt programmeme, which already compiled data over three decades.

Data management

Scientific data will be submitted to PANGAEA upon publication as soon as the data are available and quality-assessed. We expect all data from InSIDe to be available within a maximum of two years after completion of the expedition. Buoy data will be available in near-real time through the online portal www.meereisportal.de, and will be embedded into different international data bases, as through the International Program for Antarctic Buoys (IPAB).

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2.2 Boundary Layer Meteorology using a wind lidar

G. Heinemann (Uni Trier), R. Zentek (Uni Trier)

Objectives

The representation of the atmospheric boundary layer (ABL) in the Antarctic is a major challenge for numerical weather forecast models and regional climate models. Reference data sets are rare, particularly over the ocean areas. The group of the University of Trier will perform measurements of vertical and horizontal profiles of wind, turbulence and aerosols in the Weddell Sea area. Particularly in the areas of coastal polynyas, the knowledge of wind profiles is of great interest, since the coupling of the ocean with the ABL determines sea ice production and associated formation of High-Salinity Shelf Water (HSSW).

Work at sea

We will use a “Halo-Photonics Streamline“ wind lidar, which is a scanner and can operate with a maximum range of 10km. The operation principle of the lidar is backscattering at aerosol particles and clouds and the use of the Doppler effect. The lidar operates at a wavelength of 1.5 µm with a pulse rate of 20 kHz and is eye-safe (class 1M). Values are typically averaged for 1 … 30 minute intervals (wind vectors), but also instantaneous values can be measured using 0.1s intervals. The used lidar has a programmable scanner, which enables vertical scans as well as range-height indicator (RHI) and horizontal scans. The RHI mode allows for measurements of e.g. convection structure over the ocean or the internal boundary layer at the sea ice edge or ice shelf front.

Data management

The measurements during the *Polarstern* cruise PS96 ANT XXXI/2 shall yield a data set of continuous and high-resolution vertical profiles of wind, aerosols and turbulence. Continuous sampling of vertical profiles with be performed during the cruise in the Weddell Sea. For special observation periods (SOPs), RHI and horizontal scans will be performed. The focus of the SOPs is cross-sections over the polynya at the ice shelf front or at the sea ice front. Additional radiosondes will be launched during SOPs. The data will be used in a DFG project for the verification of simulations using a regional climate model.

2.3 Hydroacoustic and geology

J.E. Arndt (AWI), J.G. Nistad (AWI), H. Grobe (AWI), C.-D. Hillenbrand (BAS)

Objectives

Accurate knowledge of the seafloor topography, hence high resolution multibeam swath bathymetry data, is key, basic information necessary to understand marine processes and the glacial history of polar continental margins. It is of particular importance for the interpretation of oceanographic, geological and biological data in a spatial context. Density defined flow paths of bottom water masses are topographically controlled. For a reconstruction of the flow patterns of water masses on the shelf, it is therefore particularly necessary to have information on the regional slope of the seabed and its topographic features, such as troughs, basins and sills. The flow of water masses from the shelf to the deep sea is often controlled by canyons, gullies and channel systems eroded into the continental slope and rise, which also act as conduits for sediment transport (especially during glacial periods). For geological studies, bathymetry data can moreover provide valuable information on the glacial history of an area by revealing the geomorphology of the seafloor, i.e. sub- and proglacial bedforms. Potential sediment depo-centres and areas of erosion can be identified by combining data on seafloor topography collected with swath bathymetry systems with information about sub-seafloor composition and stratigraphy derived from acoustic sub-bottom profiling. Seafloor depressions, for example, may act as sediment traps, whereas steep slopes and escarpments are often affected by erosion, thereby exposing old, hard and laterally variable substrate. High resolution acoustic sub-bottom profiles provide information not only about the composition and stratigraphy of the top 10s of meters below the seafloor but also on the lateral extension of sediment successions. Supported by data from marine sediment cores, which will allow for the development of a chronological framework, this information can be used for palaeoceanograpic reconstructions and sedimentological studies. Furthermore, seabed topography and seafloor substrate are key environmental parameters for benthic ecosystems, and consequently their characterisation will allow for habitat classifications.

Only sparse bathymetric and sub-bottom information exists for the survey area seaward off the Filchner and Ronne Ice Shelves. The bathymetric models for this part of the Weddell Sea are mainly derived from satellite altimetry, which is heavily affected by persistent sea-ice cover, with only limited direct sounding measurements. For detailed survey planning, the satellite altimetry derived bathymetry often lacks the resolution necessary to identify small- to meso-scale topographic features. This is especially true for glacial-geomorphological seabed features, such as mega-scale glacial lineation, moraines, and drumlins. Also sedimentological features related to bottom currents, such as scours and sediment waves, cannot be resolved from satellite altimetry data. Therefore, ship-borne high resolution bathymetry surveys in the study area are required for reconstructing palaeo-ice drainage patterns and bottom current pathways. Topographically steered flows of dense water masses follow the deepest path. By interacting with the seafloor morphology these flows can result in locally enhanced or reduced bottom current strength. Enhanced bottom current flow can result in the formation of erosional or depositional features (e.g. furrows, sediment waves) that can be identified on high resolution bathymetric maps. These features can then be used to reconstruct modern and past bottom current pathways and intensities for (palaeo-) oceanographic and sedimentological studies and to provide environmental information for habitat studies.

Work at sea

The main task of the hydroacoustic/geology group is to plan and run bathymetric and sub-bottom profiler surveys using the Atlas Hydrosweep DS3 and Atlas PARASOUND P70 systems in the study area and during transit, to provide information for station planning and to collect seabed surface sediment samples with a box corer and up to 6 m long sedimentary sequences with a gravity corer for post-cruise analyses. The raw bathymetric data will be corrected for sound velocity changes in the water column and further processed and cleaned for erroneous soundings and artefacts on board. Detailed seabed maps derived from the bathymetric data will provide information on the general and local topographic setting of the survey area and on the distribution of glacial-geomorphological features on the continental shelf and erosional structures (channels, gullies) and depositional features (slumps, slides, fans) on the slope and rise. Simultaneously recorded acoustic sub-bottom profiler data will assist in characterising the sedimentary architecture of the seafloor substrate. High resolution seabed and sub-bottom data recorded during the surveys will promptly be made available for site selection and cruise planning. Sediment samples will be collected for multi-proxy (palaeo-)environmental studies and for dating the formation of geomorphological features. The acoustic surveys will be carried out by three operators in a 24/7 shift mode.

Preliminary (expected) results

Expected results are high resolution bathymetric and geomorphological maps, information on the seabed composition and sub-seafloor stratigraphy of the area offshore from the Filchner and Ronne Ice Shelves. The bathymetric, acoustic sub-bottom profiler and sedimentological data will be analysed to reconstruct the glacial history of the southern Weddell Sea shelf, to study the pathways of water masses on the continental margin of the Weddell Sea embayment and to provide environmental information for biological habitat studies in this area.

Data management

The raw multibeam echosounder data collected during the expedition and the data from sediment cores will be stored in the PANGAEA data repository at the AWI. Processed hydroacoustic data are stored at the AWI and can be requested at infobathy@awi.de. Bathymetric data sets will be provided to mapping projects and included in regional data compilations, such as the International Bathymetric Chart of the Southern Ocean (IBCSO) and the General Bathymetric Chart of the Ocean (GEBCO).

3. BIOLOGICAL AND ECOLOGICAL INVESTIGATIONS

3.1 Phylogeny, phylogeography and population genetics of High Antarctic biota

C. Held (AWI; not on board), K. Kocot (currently: Uni Queensland; as of January 2016: Uni Alabama and Curator of Invertebrates, Alabama Museum of Natural History), R. Zapata Guardiola (ICM-CSIC), H. Christiansen (AWI), C. Sands (BAS)

Objectives

The objective of the Genetics Group is to improve understanding of Antarctic animal diversity, distribution, population genetics/phylogeography, and phylogeny. Although each of the four members of this team have different backgrounds and taxonomic expertise, we all share an interest in understanding how marine organisms are genetically and physically structured in the Southern Ocean. Briefly, the background and specific objectives of each researcher on the team will be outlined.

Kevin Kocot's research addresses the taxonomy, phylogeny, and comparative genomics of marine invertebrates, especially molluscs, entoprocts, and ctenophores. Kevin is also studying the evolution of biomineralization in molluscs and their relatives and deep metazoan phylogeny, particularly relationships within Lophotrochozoa (=Spiralia) and relationships among non-bilaterian animals. Kevin's objective during the cruise is to collect specimens to help advance these projects, thus improving understanding of the evolution of animal body plans and the genomic machinery that underlies them. During PS 96, Kevin will focus on collecting specimens of Aplacophora, Polyplacophroa, and Scaphopoda. However, because he is broadly interested in deep metazoan phylogeny, he also aims to collect specimens of some non-molluscan taxa (primarily Lophotrochozoa, Hemichordata, and Priapulida).

Rebeca Zapata Guardiola is a postdoctoral researcher at Institute of Marine Sciences in Spain on a project called “El Mar a Fons.” Currently, Rebeca is involved in the PRISTANT Project. The goal of this project is to define structural conservation reference patterns (descriptors) from the pristine Antarctic communities as a framework to determine the level of disturbance in other marine communities around the world. During PS 96, Rebeca will collect and identify gorgonians. Her objectives are to 1) determine structural parameters (densities, demography, distribution) of different gorgonian species, 2) determine the age of several gorgonian species (how old are species and populations), and 3) understand the connectivity among gorgonian populations (ratio of sexual vs asexual reproduction in modular organisms).

Henrik Christiansen is a Ph.D. student at The University of Leuven in Belgium. In the scope of Henrik's Ph.D. project on the dispersal and connectivity of several species of notothenioid fish (particularly *Notothenia rossii, Notothenia coriiceps, Dissostichus mawsoni*, and *Trematomus spp*.), samples from fish collected from locations around the Antarctic continent will be compared genetically to assess connectivity at different levels. Consequently the main objective of this cruise for Henrik is to sample notothenioid fish at different locations within the Weddell Sea, such as for example off *Neumayer* and Halley stations, and in the proximity of the Filchner Ice Shelf. Samples from sites sampled during this cruise as well as those taken during PS 82 in 2014 will ensure temporal stability during marker development. Furthermore, through comprehensive sampling in this area in conjunction with detailed hydrographic information fine scale connectivity patterns can be resolved.

Chester Sands is a researcher at the British Antarctic Survey (BAS). His major interest is the inference of processes that underlie observed patterns of invertebrate diversity, principally of brittle stars (Echinodermata, Ophiuroidea). He has been collecting ophiuroids from various regions of the Southern Ocean since 2008. Of the 20,000+ specimens collected, nearly half have been identified to species and 4,000 have DNA barcodes. These data have shown that the Weddell Sea ophiuroid fauna is intriguing as despite a circulating gyre and the reasonable hypothesis of free connectivity between all shelf regions, there appears to be disjunct populations in the north and the east, with the samples from the Larsen area originating from populations sampled from all around the Antarctic continental shelf. This indicates that this species can disperse but there is some restriction on recruitment in certain regions.

Christoph Held is a Senior Researcher at AWI who conducts biodiversity surveys in the Antarctic and Subantarctic with a broad geographic coverage and a keen interest in applying molecular techniques. Having recently completed surveys in the Bellingshausen, Amundsen, and Ross Seas, the material collected during PS96 in the eastern and southern Weddell Sea will fill gaps in our knowledge of species occurrences and distribution ranges. The Filchner area appears to be a hotspot of benthic life that is unique in being located a extremely high latitudes. Does the faunal diversity and composition respond to this uniqueness? How close are its ties to lower latitude communities close-by, and is there any indication of a connectivity to similarly high-latitude communities in the Ross Sea? Another interesting point is the connection of the bottom-dwelling filter feeders to the “hanging garden” community underneath the shelf ice in the Drescher Inlet (see research project led by H. Bornemann).

Work at sea

During the cruise, the Genetics Group will collect samples primarily using Agassiz and bottom trawls. Although each researcher of this team has a taxon or selected set of taxa of interest, we will be opportunistic in our sampling and take advantage of the biological diversity recovered by fixing specimens or tissue samples of as many species a possible. Sufficient numbers of specimens or tissue samples for population genetics or phylogeography studies will be taken whenever possible. Sorting will be performed as quickly as possible keeping specimens in seawater on ice in the wet lab our on deck as much as possible. Taxa known to possess endogenous nucleases that result in rapid degradation of DNA upon death (e.g., Crustacea and Ophiuroidea) will be given top priority during sorting to ensure that the collected specimens are suitable for any downstream studies. Specimens will be photographed with a scale and their label and identified as accurately as possible in a short amount of time. Fixation will follow a standard approach where morphological vouchers are preserved using the best method for that taxon (usually fixation in 10 % formalin followed by later transfer to 70 % ethanol for storage) and specimens or tissue samples are fixed for molecular work using 100 % ethanol (DNA-based work) or RNAlater (DNA- or RNA-based work) or frozen at -80°C (DNA-, RNA-, and protein-based work as well as genome size estimation).

Expected outcome

The outcome K. Kocot expects from participating in this cruise are

1. providing specimens for the sequencing of a scaphopod genome, which is funded by his new position's start-up and will be used to study molluscan phylogeny and biomineralization (see below),
2. contribution to ongoing projects addressing the phylogeny of Aplacophora, Polyplacophora, and Scaphopoda,
3. contribution to an ongoing project examining the evolution of biomineralization in Mollusca using transcriptomics,
4. contribution to a project addressing relationships among lophotrochozoan phyla using a phylogenomic approach, and

5. description of new species of aplacophoran and scaphopod molluscs and documentation of species distribution.

R. Zapata Guardiola Zapata expects to find very well preserved and very long-lived multispecific gorgonian communities, and populations are expected to have a clustered and patchy distribution where majority of organisms have an asexual reproduction inside populations (key strategy for less interconnected areas).

H. Christiansen will use purified DNA for genetic marker development on a genomic scale (RAD sequencing), particularly for *Trematomus spp*., for which such genomic resources do not yet exist. Inferred genotypes will be analysed to determine genetic population structure, demography, and adaptive potential of Antarctic fish. Fine scale connectivity and genomic variation patterns can ultimately be related to environmental predictors.

C. Sands is working towards a comprehensive exome capture programme in which representatives of each species will be sequences for 1,500 genes for phylogenomic evaluation of molecular systematics and targeting and testing specific evolutionary hypotheses. He is also involved in two "sea scape" genetic projects involving Weddell Sea ophiuroids, using many thousands of genetic loci (restriction associated sequencing; RAD) to better understand the role of currents and dispersal ability. Furthermore he is investigating the connectivity of Antarctic benthos with that of other continental shelf fragments and shallow seas outside of the Southern Ocean.

C. Held will identify the crustacean fauna using morphological and molecular methods, clarify cryptic species, if any, and deposit species' barcodes in public databases. The samples taken during PS96 complement similar efforts elsewhere in the Antarctic. Species that have multiple occurrences will be analysed using highly variable molecular markers in order to estimate genetic exchange on various geographic and temporal scales. These estimates contribute greatly to our understanding of the evolution of adaptation to local climatic conditions.

Data management

The genetic barcodes for species identification will be deposited in the barcoding of life database BOLD (www.barcodeoflife.org). Where applicable, other data types will be deposited in suitable existing databases but will be linked to in the PANGAEA and SCAR-MarBIN databases.

3.2 Cold adaptation *vs.* sensitivity to climate change and pollution in Antarctic Notothenioids: Physiological plasticity, genetic regulation, immunology and reproductive traits

F.C. Mark (AWI), , N. Koschnick (AWI), , H. Scheuffele (AWI), A. Strobel (Uni Basel) ,
P. Burkhardt-Holm (Uni Basel), H. Segner (Uni Bern)
not on board: C. Papetti (AWI), M. Lucassen (AWI), E. Riginella (Uni Padova, ISMAR-CNR), C. Mazzoldi (Uni Padova, ISMAR-CNR), M. La Mesa (Uni Padova, ISMAR-CNR)

Objectives

The Antarctic ecosystem is progressively exposed to anthropogenic environmental influences, such as ocean warming, ocean acidification and persistent organic pollutants. It is expected that global warming will even increase levels of xenobiotics in Antarctica because they will be more available for atmospheric transport and scavenged more effectively from the atmosphere due to increased precipitation.

Antarctic Notothenioid fishes represent more than 90 % of the fish biomass on the Antarctic shelf and include more than 120 different species. They are characterized by a multitude of physiological adaptations to live in cold water. Most teleost fish inhabiting the Antarctic ecosystem are considered to be extremely stenotherm specialists, as their physiological performance is restricted to a very narrow thermal range. This thermal specialization of Antarctic fish and associated energy savings typically involve an extreme stenothermy of physiological and molecular functions, a high sensitivity to heat exposure and limited metabolic capacities to respond to changes in their abiotic environment. On the other hand, they show high reproductive investment, characterized by high gonadosomatic indexes, large eggs, prolonged gametogenesis and, in some cases, extended male parental care.

Thus, the question arises if the evolutionary highly specialized Antarctic fish possess the adaptive potential to cope with these "novel" environmental stressors. Environmental stress can strongly affect the energy balance of an organism due to the additional energy needed for metabolic compensation, acclimatisation and detoxification. An increase in basal metabolism can in turn lead to the reduced scope for activity, reproduction and growth due to the energetic trade-offs between basal maintenance and other essential energy requiring functions.

Our project focuses on the energy metabolism under environmental stress and the trade-offs between energetically demanding processes such as biotransformation, metabolic compensation and immune response of high-Antarctic fish species in response to multiple stressors (temperature, pH and exposure to xenobiotics) on the one hand and the costs for reproduction and growth on the other hand. We further will determine the level of cold adaptation in various Antarctic species and populations, red and white-blooded notothenioids, specifically from Filchner Outflow System, a biological "hotspot" in terms of food availability and physical processes. Our integrative approach aims at assessing the physiological vulnerability of high-Antarctic fish to climate change and anthropogenic pollution over several levels of biological organization from the molecule to the whole organism and to contribute to develop a basis for environmental conservation efforts.

Work at sea

By means of bottom trawls (BT) and/or bentho-pelagic nets (BPN) high-Antarctic notothenioid fish will be collected in the Weddell Sea (BENDEX Site) and the high-Antarctic waters east of the Antarctic Peninsula. Samples will be collected according to local species availability. Following a standard methodology, total length and weight, sex and macroscopic stage of gonad maturity will be recorded for each fish. We will collect and freeze blood and tissue samples of different fish species for a later analysis of the specific concentration of persistent organic pollutants.

Gonads of males and females will be removed and fixed in Dietrich's solution for histologic analysis, or in 10 % formaldehyde solution for fecundity estimation. To estimate age at sexual maturity, otoliths will be removed and stored dry. For each species, and depending on their availability, gonads of a minimum of 10 individuals per sex per stage will be preserved for morphological description. A minimum of 25 ovaries of mature females will be stored for both fecundity and egg sizes estimations, while 10 testes of mature males of different sizes will be kept for analysis of within-sex variability in gonad investment. The laboratory analyses will be performed at the Department of Biology (University of Padova) and at the ISMAR-CNR of Ancona.

We will further conduct comprehensive comparative physiological and molecular genetic studies of freshly caught notothenioid fish. For these experiments, live fish in the most pristine condition possible are needed. We will therefore use a fish lift so that we will be able to conduct our exposure experiments directly after recovery of the specimens aboard.

We will estimate of acclimatory capacities/sensitivity towards combined treatments of warming and hypercapnia:

- Analyse the expression of key regulatory enzymes after short term (48h) hypercapnia/hyperthermia exposure
- Evaluate cellular capacities to adjust metabolic pathways to high intra-cellular PCO_2 and bicarbonate. Acute and short time acclimation experiments, assessment of acute PCO_2 effects on mitochondrial metabolic pathways, enzymatic function and expression.

We will determine the level of cold adaptation by analysis of *in-situ* expression of target genes on the background of the population structure:

- Score degree of cold adaptation by blood osmolality, thermal hysteresis and levels of heat shock protein and anti-freeze glycoprotein expression
- Sampling of fish for determination of comprehensive *in-situ* mRNA expression profiles from differing thermal habitats to identify critical processes and thresholds in comparison to responses in acclimation experiments
- Sampling of fish for determination of population structure in specific species in search of genetic variability differences between groups of individuals in relation to environmental parameters, life history traits, species ecology (i.e. pelagic and benthic species) and individual meta data recorded during sampling (ie. total and standard length, weight, sex, etc.)

Using freshly excised liver, head kidney and spleen tissue, we will use tissue homogenates and isolated cells for different experimental approaches:

- Assess the single and combined effect of warming and environmental chemicals on liver energy metabolism of various Antarctic fish species. For this purpose, we will measure hepatocyte respiration during exposure to different toxicant concentrations and rising temperatures.
- Expose liver and immune cells to xenobiotics and increased temperatures to examine the impact of the altered environmental conditions on the activities of selected enzymes in the cells. The enzyme activities can be used to indicate a potential damage or shifts in metabolic pathways due to chemical exposure and thermal stress. The photometric assays will include e.g. antioxidative enzyme activities, assays of cytotoxicity, glycolysis and anaerobic metabolism.
- Analyze the expression of cytokines and complement genes to assess a possible impairment of the immune response of Antarctic fish due to toxicants.

Last but not least, we will maintain live fish in a recirculating aquarium system onboard (aquarium container AWI 502401) until the arrival in Punta Arenas, from where they will be shipped to the Alfred Wegener Institute in Bremerhaven.

Data management

All data will be made available in the open-access data repository PANGAEA.

3.3 Suspension feeders in a biodiversity hotspot: Sponge distribution and functioning on the eastern Antarctic shelf

D. Janussen (not on board), D. Kersken (Senck.F)

Objectives

Sponges are sessile suspension feeders and play a key role in the Antarctic marine benthic community structures and dynamics as they form a dominant component of many macrobenthic communities in the Southern Ocean. The connection between ecological driving forces and sponge distribution patterns enables us to draw general conclusions from macrobenthic biodiversity patterns on a large and intermediate spatial scale. Furthermore, many ecological functional roles are distinctly shaping macrobenthic communities as sponges contribute to to bentho-pelagic coupling processes, substrate formation, associate with other organisms and synthesize secondary metabolites. Antarctic sponge species are outstanding due to their high level of endemism which can be explained by geographical and physical long-term isolation mechanisms. Main objective of this study is an investigation of bentho-pelagic coupling, adaptation and recolonization processes as well as an analysis of biodiversity and community structure of sponge assemblages to contribute to the characterization of the Filchner outflow region and adjacent shelf areas in the southern Weddell Sea which are known as a biodiversity hot spot.

Work at sea

The investigation of bentho-pelagic coupling and adaptation processes will be conducted by combination of sponge community data and measurements of environmental parameters in the bottom water layers, such as current regimes, water depth, dissolved silica, salinity and temperature. Recolonization processes can be traced back to events of intermediate environmental disturbance (e.g. iceberg scouring or sudden nutrient input by local algae blooms) as they can trigger sponge reproduction cycles. Underwater photos and video material from ROV dives are suitable for such analyses. Species identification for the planned community analysis will be based on material from AGT catches and underlie an approach of sponge taxonomy (spicule and histological preparations) combined with DNA barcoding (COI, 16S, 18S and 28S). Furthermore, subsampling of single specimens from AGT and/or ROV catches will be conducted for other investigations: (1) screening for secondary metabolites and long chained fatty acids, (2) sponge biomass-size calibration and (3) food-web analysis based on stable isotope investigation.

Data management

The sponges collected and investigated in the frame of our Antarctic research projects are deposited and inventorized in the Porifera collection of the Senckenberg Research Institute and Nature Museum. All identified material, including metadata, is catalogued in the SESAM Database (Senckenberg Sammlungsmanagement) and each sample is labelled with an SMF-No. SESAM data are online available immediately upon registration and approval by the collections manager. GBIF (Global Biodiversity Information Facility) and EurOBIS (European Ocean Biogeographic Information System) regularly scan and retrieve the current data of SESAM, so our data become available there as well. Data on Antarctic sponge species are futhermore registered by RAMS (Register of Antarctic Marine Species), available via the SCAR-MarBIN data portal. Genetic sequences will be submitted to NCBI (National Center for Biotechnology Information) prior to publication.

3.4 Sponge ecology and benthic fluxes

C. Richter (AWI), L. Federwisch (AWI), N.N. (AWI), M. Holtappels (AWI), R. Johansson(SLC Uni Gothenburg), E. Andersson (SLC Uni Gothenburg)

Objectives

On Antarctic shelves, sponges often dominate the megabenthic epifauna, but their ecological significance for Southern Ocean shelf ecosystems is virtually unexplored. Sponges are active suspension feeders which are believed to be governed by the strong seasonality in primary production, resulting in an ample supply of pelagic food to the benthos during the sun-lit summer season and a presumed paucity of food in the dark and ice-covered winter months. Long periods of food deprivation are, however, difficult to reconcile with the observed richness of sponge communities in many parts of the Antarctic. Sponges are believed to filter minute picoplankton (<2 µm), which in the aphotic zone of Antarctic shelves is likely to be dominated by bacterioplankton. We therefore hypothesize that this food source may be partially decoupled from pelagic primary production: diatom blooms forming in the stratified surface layers of the retreating ice edge/shelf ice polynyas sink out to the seafloor where they are decomposed near the seabed. Resuspension of this detritus may fuel a microbial loop in the benthic boundary layer supplying sponges for extended periods. The objective of this study is to test this hypothesis and close the gap in Antarctic ecological process studies relating benthic boundary layer findings to the processes in the overlying water column. Here, we combine pelagic work on plankton and benthic work on sponges, on the organismal and system level.

The main objectives are:

- to assess the diet, feeding rates and metabolism of sponge assemblages on the shelf of the south-eastern Weddell Sea, providing results comparable with those from other sponge-dominated areas
- to assess the benthic oxygen fluxes using Eddy Correlation (EC) systems in sponge and non-sponge dominated communities relative to ice-scour barrens
- to assess the flux of C and Si from the surface to the seabed, and its re-mineralisation using a short-term mooring
- to identify spatial distribution patterns of sponges in relation to bottom-up (food, Si) and top-down factors (predators) governing sponge occurrence at local and regional scales
- to assess the status of the recovery of sponge communities in the area of the long-term benthic disturbance experiment (BENDEX) started in 2003, in comparison with sponge development in the Larsen area

Work at sea

Within the context of the overall benthic ecological working programme of the PS96 cruise, seabed imaging will be carried out with a Remotely Operated Vehicle (ROV) at about 10 stations, including the BENDEX site. The ROV is equipped with HD video, still camera and CTD to investigate the abundance, distribution, composition and diversity of sponges in an environmental context. The ROV also has a manipulator and syringe water system to collect material and water samples. Water samples taken from the exhalant and inhalant currents of sponges will allow us to determine retention efficiencies for particles. Fluorescein dye experiments will allow the determination of pumping rates. The combination of the two will provide filtering rates for picoplankton. Dissolved oxygen and dissolved silicate samples will be analyzed to assess metabolism and Si deposition. A short-term mooring with remote access sampler (RAS), CTD-multiprobe, ADCP current meter and sediment trap will be deployed to track the build-up and sinking of pelagic primary production and its transformation near the seabed. An Eddy Correlation system will be deployed to assess the fluxes of oxygen in sponge and non-sponge dominated benthic communities and sediment areas. Repeat transects of ROV tracks carried out during earlier cruises will allow to monitor changes in sponge communities and other benthic groups over time and help assess the dynamics of benthic communities over longer time scales.

Data management

Seabed video and still images as well as the environmental and EC data will be made available in open-access data repositories: seabed images and metadata in PANGAEA and faunistic data in AntaBIF (Antarctic Biodiversity Information Facility).

3.5 Spatial distribution patterns of epibenthic megafauna

D. Piepenburg (AWI)

Objectives

Megabenthic epifauna comprises the seafloor organisms that are large enough to be visible in seabed images and/or to be caught by towed sampling gear. They are of very high ecological significance for Southern Ocean shelf ecosystems, as they strongly affect the small-scale topography of seafloor habitats and, hence, the structure of the entire benthic community. In addition, some species are especially sensitive to environmental change, due to their slow growth, specific reproduction mode, high degree of environmental adaptation, and narrow physiological tolerances, and can thus serve as early indicators of ecosystem shifts in response to environmental change. Based on investigations performed during previous *Polarstern* cruises to the southeastern Weddell Sea, we will carry out comparative follow-up field studies, the main objectives of which are:

- Complement surveys of mega-epibenthic assemblages of the shelf of the southeastern Weddell Sea, providing results comparable with those from earlier studies
- Identify spatial distribution patterns of epibenthic megafauna at local and regional scales
- Assess the status of the recovery of megabenthic communities in the area of the long-term benthic disturbance experiment (BENDEX) started in 2003
- Contribute to the standardization of the classification of Antarctic megabenthic communities

Work at sea

Within the context of the overall benthic ecological working programme of the PS96 cruise, seabed imaging will be carried out at about 20 stations, including BENDEX sites, along transects of about 2 nm length each by means of the Ocean Floor Observation System (OFOS). This gear is equipped with both a still-photo and a video camera, to investigate the abundance, distribution, composition and diversity of epibenthic megafauna. If feasible, OFOS stations will be placed such that different benthic habitats are covered by the imaging surveys. Macro- and megabenthic fauna collected from concomitant trawl catches at the same or nearby stations will be used to aid identification of the organisms visible in the seabed images. The combined results will serve as a case study for developing a first general standardisation scheme of Antarctic macro- and megabenthic communities.

Data management

Seabed images and data will be made available in open-access data repositories: seabed images and metadata in PANGAEA at latest one year after the cruise, and faunistic data in

AntaBIF (Antarctic Biodiversity Information Facility) as soon as benthic classification, quantification and identification are finished.

3.6 Tracing the effect of ice-shelf loss on benthic ecosystem functioning - from Meio to Macro

H. Link, D. Seifert (Uni Kiel), G. Veit-Köhler, Y. Bodur (Senck. W.)

Objectives

Little is known, how processes at the seafloor - benthic functions - are affected by changes in ice-cover. In this benthic environment few studies have simultaneously investigated different size classes of organisms, like meio- and macrofauna. But up to now, nothing is known about the role of these benthic size compartments for benthic functions under the influence of ice shelf loss or disturbance linked to ice-retreat. Here, we will jointly evaluate the response of benthic ecosystem functioning to the retreat of ice shelves in the Weddell Sea using two benthic functions, namely food uptake and remineralisation of inorganic nutrients, and two benthic compartments (meio- and macrofauna). During cruise PS96, the two complementary aspects of (A) trophic interactions and partitioning among meio- and macrobenthic communities and (B) the net remineralisation response to simulated ice retreat will be studied. Using incubation of sediment cores with inhabiting meio- and macrofauna, trophic interactions will be determined using replicated pulse-chase experiments and stable isotope techniques (Fig. 3.1). In the same cores, remineralisation response will be measured as benthic boundary fluxes (nitrate, silicic acid, phosphate, oxygen) at the sediment-water interface. The effect of ice shelf loss as mechanical disturbance in the BENDEX area and as whole marine system at the Filchner Ice Shelf edge will thus be studied under both aspects.

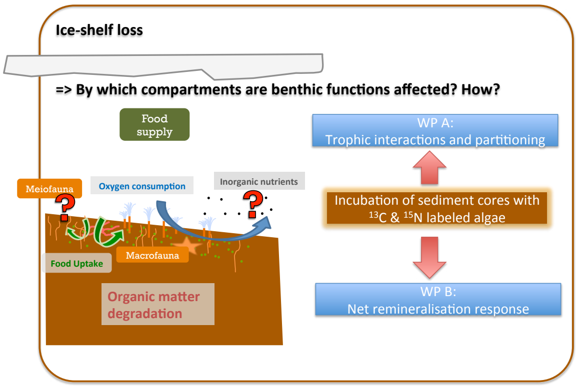

Fig. 3.1: Main study objective and approach. A simplified model of different compartments and mechanisms influencing benthic functions following ice-shelf loss shows how they relate to the work packages WP A (food uptake) and WP B (inorganic nutrients).

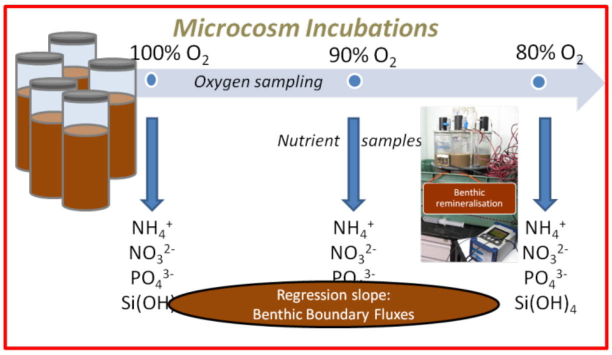

Fig. 3.2: Graphic illustration of the general sampling processing of microcosm incubations during the cruise.

Work at sea

Background geographical variation will be determined by collecting samples within and outside 2 areas influenced by ice shelf loss (Filchner-Ronne Shelf edge and BENDEX area). Onboard incubations of sediment cores obtained with the multicorer (MUC; or sub-sampled from box cores) will be run in temperature controlled conditions in the dark. During incubations, nutrient and oxygen concentrations in the water phase overlying the sediments will be monitored (Fig. 3.2). After incubations, macro- and meiofauna will be preserved for taxonomic and isotopic analyses.

Pulse-chase experiments using isotopically labeled microalgae addition are planned for additional incubation cores at 4 sites: 1 inside and 1 outside the BENDEX area, 1 at the Filchner-Ronne shelf ice edge and 1 at 20 nm distance. Ideal sites will be at ca. 400 m water depth. A total of 20 sediment cores will be collected at each of the 4 targeted sites over the course of the expedition. Before, macrofauna organisms of a later successional benthic ecosystem stage - i.e., from the already ice-free Weddell Sea area - will have been collected by means of the box corer and/or the Agassiz trawl. These organisms will be kept under controlled conditions (running sea water, 2 °C in the dark) until the experiment. 10 ml macrofauna (biovolume) will be added to 10 randomly selected cores. Incubations for benthic boundary flux measurements will be conducted after 1 and 2 weeks of increased food and fauna treatment. Cores will be cut for isotopic analyses after 2 weeks. Onboard, macro- and meiofauna samples cannot be separated and will be preserved as combined sample. Furthermore, sediment and water samples will be collected at each station to determine *in-situ* trophic structure and environmental parameters (Chl a in sediments & in water column, organic carbon concentration in sediments, natural isotopic signature of phytoplankton, sediments and fauna).

Data management

Most data will be obtained through laboratory analyses after the cruise. Processed data will be uploaded to the databases PANGAEA and/or SCAR-MarBIN.

3.7 Pelagic-benthic processes in the Filchner Outflow area: a benthic community and particulate matter perspective

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Objectives

The marine vicinities of Filchner Ice Shelf are the main area of deep and bottom water formation in the southern Weddell Sea, where the outflow of cold and fresh water from below the shelf ice mixes with the oceanic Weddell Sea Gyre waters. The resulting physical fronts presumably convert the region in a biological hotspot. This characteristic gives the study area great interest for multidisciplinary scientific research given in addition to its global influence on climate and the fact that polar regions are especially sensitive to the ongoing global warming and climate change. Thus, it is likely that this biological hotspot may be undergoing rapid transformations linked to environmental changes. On this basis, analyzing how the productive processes in the pelagic zone couple with the benthic realm offers the possibility to investigate how the actual environmental conditions are reflected in the status of the local benthic communities and the chemical characteristics of the sediment providing a baseline for a region where this information is scarce. We expect to identify how the region reacts to environmental changes and the effect of these reactions on the local biogeochemical cycles, especially those of the carbon and silicon, and the Antarctic benthos. We will compare the expected results with other areas of the Weddell Sea, where climate change already produced dramatic changes (e.g., the Larsen continental shelf) and with other regions of the Weddell Sea, where such effects are less evident (e.g., results obtained in the previous cruise PS82 to the Filchner area and the region off Austasen and Kapp Norvegia). This approach opens the door to contrast the actual situation at the spatial extremes of the Weddell Sea basin. Concerning the benthic communities, the results obtained from the expedition PS 82 have shown that the benthic community patterns in the hydrographically diverse Filchner Overflow System are more heterogeneous than previously thought.

However, heavy sea ice conditions did not allow to sample the western slope and shelf of the Filchner Depression – a region of high ecological interest, because it is totally covered by heavy sea ice for most of the time even in consecutive years. Therefore, sea ice makes this area is of special interest for the benthic work given that pelagic conditions may differ among slopes.

Another core theme of the benthic studies during cruise PS96 focuses on the BENDEX experiment, which started in 2003 to set a temporal baseline for recolonization. It consisted in an artificial mechanical disturbance in the region of Austasen to simulate the impact of grounding icebergs on benthic and demersal fish communities. As a result, benthic biomass was drastically reduced by a factor of 10. In 2011 and 2014 we revisited the BENDEX site to follow the recolonization and succession 7 and 10 yrs after the initiation of the experiment and it was observed a pronounced increase in abundance, diversity and especially in biomass. In 2011 early colonizers were juveniles of the sponge *Tethyopsis longispinus*, whereas in the last sampling campaign in 2014 the juveniles of echinoids, holothurians, asteroids, ophiuroids and pygonoids were also abundant.

The aim of the investigations during cruise PS96 is to identify characteristics of the pelagic-benthic coupling in the marine vicinities of Filchner Ice Shelf through the analysis of (a) currents, e.g., deep water coming onto the shelf, (b) abundance and distribution of benthic communities and function of selected species, (c) biochemical characteristics of the sediment, and (d) particle fluxes at the shelf edge where intense water flux exchange occurs. The main research area will be the Filchner Depression, specially the western slope, to complete the data set generated during the expedition PS82. However, a number of stations along the continental shelf from Atka Bay to the Filchner Depression will be of interest to find out whether there is a gradient in the studied variables between the two regions. Specific objectives are:

- To analyze the distribution of the particulate silicon and organic matter in the sediment column through the analyses of several variables (e.g., protein, lipid, carbohydrates, phytopigments, amino acids, fatty acids and ^{14}C, ^{210}Pb)
- To identify local characteristics of particle fluxes, currents and organic matter distribution in the sediment column in a short-scale (km) spatial distribution in a supposed highly productive polar setting
- To describe the local benthic fauna of the Filchner region in terms of abundance and biomass, especially the poorly known western slope and western flank of the Filchner trench.

Work at sea

A sediment core grid will be set covering the vicinities of the Filcher outflow path and the Filchner Depression, specially on the western flank and the slope of the Depression (Fig. 3.3). To expand our knowledge, we plan to collect benthic community and sediment samples at 10 stations with the camera-equipped giant multibox corer and the 10 cm multibox corer, respectively. In addition 4 stations in the BENDEX area will try to be revisited to assess changes in organic matter distribution since the last sampling effort in 2011. On the way to the BENDEX site, three more stations on the poorly sampled broad shelf northeast of Halley are planned.

Sediment cores will be recovered with a giant multibox corer (MG) and a multicorer (MUC), depending on the grain size and sea floor characteristics. MUC sediment cores will be subsampled on board in slices 0.5 cm to 2 cm thick, whereas MG samples will be sieved and preserved in formaline afterwards. Two conical SMT 234 sediment trap will be moored 20 and 70 m above the seabed (mas) coupled to a current meter Aanderaa RCM9 located 8 mas on the continental shelf edge at the eastern slope of the depression. Operating time for these instruments will be decided on board.

Data management

All the data generated from this expedition will be included in both PANGAEA and the Spanish Polar Database located in the Spanish Polar Committee's National Polar Data Center (http://hielo.igme.es/index.php/en/).

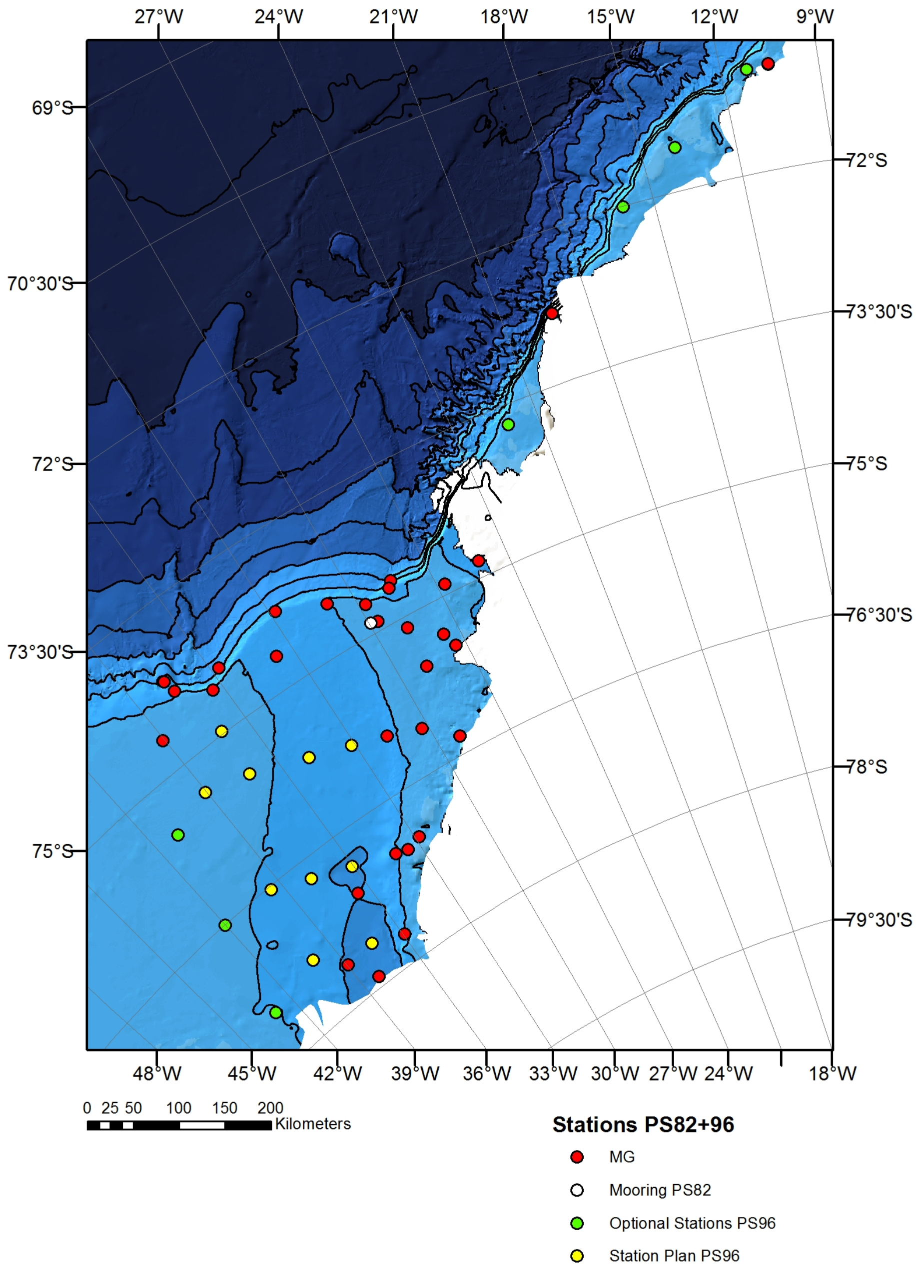

Fig. 3.3: The planned sediment core grid to be set up the vicinities of the Filcher outflow path and the Filchner Drepression and planned stations

3.8 Seal research at the Drescher Inlet (SEADi)

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Objectives

*SEAl*s at the *D*rescher *I*nlet (SEADI) represents a follow-up study of seal investigations carried out during *Polarstern*'s expedition PS82 at the Filchner Outflow System and at the Drescher Inlet in 2014 (Bornemann et al. 2014). It also complements earlier investigations at these locations initiated in 1986. Though SEADI is primarily an ANT-Land activity, it is being carried out in liaison with the research expedition *Filchner Ronne Outflow System Now* (FROSN) of *Polarstern* (PS96) that also implemented SEADI as part of its research programme. SEADI focuses on the foraging ecology of Weddell seals (*Leptonychotes weddellii*). Data obtained from seal-borne 3D-multi-channel data loggers and cameras during an earlier Drescher expedition in 2003/2004 (PS65) documented that Weddell seals dived along the steep cliffs of the shelf ice and made foraging excursions under the ice shelf (Liebsch et al. 2007; Watanabe et al. 2006). The seal-borne image and dive data led to the discovery of a hitherto unknown cryo-benthic community of marine invertebrates, presumably anthozoans (*Edwardsiella* spp., *cf*. Daly et al. 2013) and isopods (Antarcturidae, Austrarcturellidae, Aegiidae), being attached head-down to the underside of the floating ice shelf at depths of around 130-150 m (Watanabe et al. 2006). These "hanging gardens" may represent an attractive food horizon where seals could benefit from a local hotspot of high biologic activity. This particular spot could also explain the bimodal distribution of dive depths of Weddell seals known from earlier investigations during PS65, PS48, PS34, PS20, PS17 (Plötz et al. 2005, 1999, 1997, 1994, 1991). A synoptic field study at Atka Bay (*Neumayer Station II*) during austral spring 2008 also showed a bimodal distribution in dive depths and feeding events of Weddell seals with an increased feeding rate likely on smaller prey items in the pelagic realm (Naito et al. 2010). A number of seals undertook dives to shallower depths between 60 and 80 m close to the ice shelf edge and along an iceberg stranded inside the Bay, and supported our hypothesis of ice shelf associated foraging (Naito et al. 2010). However, the question whether or not these findings are representative for the far ranging high Antarctic ice shelves in general still remains open. Though the seals' diving behaviour at Drescher Inlet indicates active foraging in locally attractive feeding spots, the factors contributing to this hotspot of enhanced food availability and its stability over time are largely unexplored. In particular questions towards species composition, horizontal extent and nutrient supply of the fauna inhabiting the underside of the ice shelf are still open and call for additional investigations to further our understanding of bentho-pelagic coupling processes.

Physical environment

The Drescher Inlet is a 25 km long and 1 – 2 km wide crack in the Riiser-Larsen Ice Shelf, located at 72°50.20'S, 19°09.18'W. A recent radar scan of the shelf ice edge by *Polarstern* during PS82 indicates a shift of the inlet contour of about 20 km to the west in a period of 10 years (unpubl. data). The seabed under the ice shelf extends for over 100 km to the nearest grounding line of Dronning Maud Land (Arndt et al. 2013; Schenke et al. 1998). Bathymetric surveys reveal seafloor depths inside the inlet from 430 m in the inner section, to 380 m over a central 6-km-wide bank, and to 520 m at the inlet mouth (Graffe & Niederjasper 1997). The depth outside the inlet gradually increases, reaching the 1,000-m isobath about 3.5 km beyond the inlet mouth. Fast ice remains in the entire inlet from its mouth to the inner parts, where it can pile over several years to some meters. Beneath the fast ice, platelet ice can aggregate to layers of several meters (Thomas et al. 2001; Günther et al. 1999). The hydrography within the inlet is characterised by a stable thermo(pycno)cline between 130 and 230 m coinciding with the depth of the floating shelf ice (Thomas et al. 2001).

Biological environment

An estimated aggregation of about 300 Weddell seals (*Leptonychotes weddellii*) is regularly associated with the inlet. The seals haul out along tidal cracks in the fast ice and adjacent to the cliffs of the ice shelf during summer. By mid December their offspring is weaned and mainly (non-lactating) adult female and male Weddell seals in the moult and first of the year juveniles are present on the inlet's fast ice. Strong wind and gales may initiate break-up of the formerly consolidated fast ice towards the end of summer. When the ice cover recedes, also other pack ice seals, mainly crabeater seals (*Lobodon carcinophaga*), but also leopard (*Hydrurga leptonynx*) and Ross seals (*Ommatophoca rossii*) were observed during earlier research campaigns, as well as Antarctic minke whales (*Balaenoptera bonaerensis*), Arnoux beaked whales (*Berardius arnuxii*), and killer whales (*Orcinus orca*) patrolling in the leads of the disintegrating fast ice of the inlet (H. Bornemann, pers. obs.). Also other marine endotherms, such as the emperor penguin with a colony of an estimated 7,000 breeding pairs are resident in the inlet (*cf.* Fretwell et al. 2012; Wöhler 1993; Reijnders et al. 1990; Klages & Gerdes 1988; Plötz et al. 1987; Hempel & Stonehouse 1987; Plötz et al. 1987). Their chick rearing period will come to an end towards the end of January (Pütz & Plötz 1991), and only moulting (sub)adult birds and chicks will be present on the sea ice afterwards. The pelagic and demersal fish fauna in the inlet is dominated by the nototheniid *Pleuragramma antarcticum* (Plötz et al. 2001); abundance and biomass of other species of the families Nototheniidae (*cf.* Gutt 2002), Channichtthyidae, Bathydraconidae, Artedidraconidae and others seem to be much lower (Plötz et al. 2001). However, krill (*Euphausia* spp.), gelatinous plankton and amphipods seem to be abundant in considerable amounts (Plötz et al. 2001; Günther et al. 1999). The epibenthic community, as far as it is known, is in comparison with other areas along the east coast of the Weddell Sea, especially north of the Drescher Inlet, relatively poor in life forms and biomass (J. Gutt, pers. com.).

Work on ice

SEADI will replicate earlier studies on Weddell seals and their prey in a season that is characterized by unbroken ice and permanent daylight. Research will be facilitated due to a temporary *field camp*. Weddell seals will be instrumented with still cameras in order to obtain *seal-borne image data* on the under shelf ice fauna, and to document encounters of zooplankton, krill and fish, both in the pelagial and benthal. Ross seals might also be instrumented upon their presence in liaison with a concurrent research study undertaken by collaborating scientists of the Mammal Research Institute (University of Pretoria, RSA) on RV *SA Agulhas II*. The Remotely Operated Vehicle (ROV) V8sii (Ocean Modules®) equipped with twin high-resolution cameras will be deployed to provide *ROV-borne footage* and samples of the "hanging garden" biota with accuracy unavailable to seal-mounted cameras. *CTD-combined satellite-linked time depth recorders* will provide data on dive depth, spatial movement and *in situ* hydrography under the sea ice. *Additional sampling* of blood and whiskers will provide material for post hoc analyses of stable isotopes. All *animal handling* procedures require chemical immobilisation.

Field camp

Research will be conducted by a field team of four people at a temporary field camp that will be located on the shelf ice in the vicinity of the inlet. An ice ramp allows commuting between camp and inlet fast ice with snowmobiles. Station facilities of the Drescher campaign comprise of two fiberglass igloos (one each as living quarters, one igloo for kitchen and provisions), one Polarhaven tent as workshop, and two Scott tents. For the power supply two 5kW, and two 1kW-generators are used alternately. Main consumers of electricity are two snowmelts for producing water, fan heaters to dry the working clothes and snow boots, and the ROV. Cooking and basic heating is done with propane. Three snowmobiles (Skidoo) and Nansen-sledges provide the necessary mobility for the fieldwork. Pop-up tents and a canopy-covered sledge will shelter the equipment on the sea ice. Depending on weather conditions, the maximum daily energy consumption amounts up to 25 litres of fuel and approx. 1.5 kilograms of gas. All wastes of glass, plastic, metal, paper, sewages and faeces are kept in separate tubs, which are then brought back to the ship. The igloos and tents and all other equipment will be dropped-off by helicopters onto the ice shelf to provide accommodation and working facilities for four people for 35 days. Transportation of the equipment will require approximately 30 shuttle flights. The camp can be completely equipped (and at the end of the field campaign removed) within a few hours. In order to guard against strong snowdrifts, the igloos and tents are lined-up across the main easterly wind direction. Alternative campsites as a result of potentially unfavourable weather or sea ice conditions are envisaged at the Atka Bay with a direct liaison and support via *Neumayer-Station III*, and at another inlet in the vicinity of the research station *Halley VI*.

Seal-borne image data and ROV footage

Up to 15 Weddell seals will be instrumented with Infra Red (IR) still picture camera loggers (Little Leonardo®, Japan) in order to track their foraging behaviour during the course of the study and to investigate the seals' under shelf ice foraging dives. The seal camera system is being used in collaboration with scientists from the National Institute of Polar Research and the Biologging Institute (Tokyo, J). The units will have to be retrieved about four to eight days after deployment in order to download the images (Naito et al. 2013). Seals will be immobilized (see below) to achieve a reliable attachment of the logging and transmitting devices and concurrent sampling of tissue, and for the retrieval of the archival tags. Particular attention will be paid to extend earlier findings on the foraging behaviour under the shelf ice. Thus, animals will be instrumented preferentially in the proximity of the shelf ice edge. Operations of the Remotely Operated Vehicle (ROV) V8sii (Ocean Modules®) under the ice shelf support this part of the study. The 360 degree concept allows to fly the ROV also in upside down mode to assess the hanging gardens under the shelf ice in its oceanographic setting using DVL navigation and oceanographic sensors. A mini-dredge and sampling box attached to the upper side of the ROV will be available to try to provide material for genetic investigations. The 500 m rated inspection class ROV with twin HD cameras and oceanographic sensors will also be deployed to simultaneously assess the benthic biota and environment. Footage along transects allow a classification of megabenthic communities in the inlet.

CTD-combined satellite-linked time depth recorders

This approach concentrates on the deployment of satellite transmitters on seals on the sea ice in order to get data on the seals' foraging behaviour and concurrent *in-situ* hydrographic data within and beyond the area of the Drescher Inlet. The CTD Satellite-Relay Data Logger (CTD-SRDL, Valport®, Sea Mammal Research Unit, UK) measures temperature, pressure and salinity and transmits data along with seal positions to satellites when the seals surface. These units may remain with the seals in order to extend the study for information on residence times towards the end of the annual moult (February - September). Long-distance tracking of marine mammals in the Southern Ocean by satellite relies on the ARGOS system. ARGOS satellite transmitters for marine mammal applications are designed to provide the animals' at-sea locations and transmit data to the satellites when the seals surface. CTD-SRDLs have the capabilities to record also *in-situ* water temperature and conductivity for the entire migrations of tracked seals. Such data are of suitable quality to characterise the oceanographic settings utilised by seals (e.g. Meredith et al. 2011; Boehme et al. 2009; Nicholls et al. 2008), and are complementary to the oceanographic investigations to be carried out during FROSN. So far only three publications provide evidence for extended residence times of satellite-tracked Weddell seals within the Weddell Sea (McIntyre et al. 2013; Årthun et al. 2012; Nicholls et al. 2008). During the annual moult the units will be shed, and thus tracks and concurrent behavioural as well as hydrographic data can be collected over a period of one year at maximum. The reconciliation of data on the seals' diving behaviour and on the hydrographic features with information on the occurrence and biomass of the seals' prey aims to contribute to the understanding of the upper trophic level interactions at the Drescher Inlet. Adult Weddell seal males (*Leptonychotes weddellii*) will be preferably instrumented with CTD-SRDLs, since they can be expected to remain in the investigation area throughout the year due to their "maritorial" behaviour. Weddell seals, furthermore, dive to depths of up to 900 m (Årthun et al. 2012), and their foraging dives can yield information on both potential pelagic and demersal or benthic prey in the investigation area. The deployments of CTD-SRDLs will preferably take place after the seals have completed their annual moult. The devices will be glued to the new fur of anaesthetized seals using quick setting epoxy resin. Up to 5 CTD-SRDLs will be deployed.

Additional sampling

On top of the instrumentation, a blood sample of 30 ml will be taken together with hair and whisker samples. Blood samples will be centrifuged, separated in red blood cells and serum and both later on board *Polarstern* deep frozen at -80°C. Within the serum fraction we aim to analyse for prey specific biomarker proteins that allow for reconciliation with the seals' prey spectrum (e.g. octopine in octopods, specific amines in fishes, homarines and dimethylsulfoniopropionate in molluscs and crustaceans) in later laboratory analyses (*cf.* Eder et al. 2010 Eisert et al. 2005; Ito et al. 1994; Hochachka et al. 1977). These data can hint at the recent prey spectrum within a couple of days prior to blood sampling using both serum and blood cell fractions. The hair and whisker samples will be used to get retrospective information on the prey spectra on intermediate time scales up to a couple of months by means of component-specific isotope analyses (*cf.* Hückstädt et al. 2012a, 2012b; Newsome et al. 2010; Lewis et al. 2006). *In-situ* collection of naturally regurgitated vomitus, faecal samples, etc., complements the sampling protocol.

Animal handling

For the purpose of instrumentation, the seals need to be anaesthetized following the methods as described in Bornemann et al. (1998) and Bornemann & Plötz (1993) or Bornemann et al. (2013). Drugs are initially administered intramuscularly by remote injection using blowpipe darts. Follow-up doses are usually given intramuscularly by direct manual injection or in rare cases intravenously. The dose regime involves the drugs as listed below and dosages or respectively dose ranges vary depending on initial or follow-up injections. The seals will be immobilized with ketamine/xylazine (Weddell seals) or with tiletamine/zolazepam (Ross seals) combinations. Depending on the course of the immobilisation, dosages need to be individually adjusted and will be complemented by the same drug to maintain or extend the immobilisation period on demand. Benzodiazepines (diazepam or climazolam) may be needed to attenuate muscle tremors. Atipamezol will be used to reverse the xylazine component in the xylazine/ketamine immobilisation, and flumazenil may be used as antidote for the unlikely situation of an overdose of benzodiazepines. Doxapram is exclusively reserved for the unlikely necessity to stimulate breathing in the case of extended periods of apnoea, when mechanical obstructions of the upper airways can be excluded. The length and girth of each seal will be measured. All procedures are carried out pursuant to the SCAR Code of Conduct for Animal Experiments.

Expected results

In particular insights into the species composition, horizontal extent and nutrient supply of the fauna inhabiting the underside of the ice are expected from seal-borne and ROV imagery. From each of the CTD-SRDL tagged seals we expect per day about 4 temperature, salinity and depth profiles almost in real time which will allow us to study how changes in the underwater environment alter prey distribution beneath the ice as indicated by the seals' individual diving and foraging behaviour. We furthermore expect that these key physical oceanographic variables collected from hitherto under-sampled coastal shelf regions may assist the refinement of computer models of the Southern Ocean circulation. Sampling of blood and other material will provide information on the seals' prey spectrum in subsequent laboratory analyses. Combining the data obtained from the different systems, allows to characterise the foraging strategies of the Weddell seals and to quantify their pelagic and benthic foraging. A synthesis will provide new insights into the complexity of intermediate and upper level trophic interactions and energy flows in pelagic and benthic food webs.

If successful, the retrieval of invertebrate samples by the ROV will enable the first genetic investigation of the species inventory of the "hanging garden" community. Species barcodes will be deposited in the barcode of life database (www.barcodeoflife.org) and the phylogenetic and population genetic connections of the under-ice fauna to epibenthic communities will be studied.

Data management

All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de), and will be attributed to a consistent project label denoted as "Marine Mammal Tracking" (MMT, see http://www.pangaea.de/search?q=project:label:mmt).

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	Zentek	Rolf	Uni Trier	Scientist, meteorology

6. SCHIFFSBESATZUNG / SHIP'S CREW

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1.	Wunderlich, Thomas	Master
2.	Grundmann, Uwe	1.0ffc.
3.	Westphal, Henning	Ch.Eng.
4.	Lauber, Felix	2.0ffc.
5.	Kentges, Felix	2.0ffc.
6.	Peine, Lutz	2.0ffc.
7.	Scholl, Thomas	Doctor
8.	Hofmann, Jörg	Comm. Offc.
9.	Schnürch, Helmut	2. Eng.
10.	Buch, Erik-Torsten	2.Eng.
11.	Rusch, Torben	2.Eng
12.	Brehme, Andreas	Elec.Tech.
13.	Ganter, Armin	Electron.
14.	Dimmler, Werner	Electron.
15.	Winter, Andreas	Electron.
16.	Feiertag, Thomas	Electron.
17.	Schröter, Rene	Boatsw.
18.	Neisner, Winfried	Carpenter
19.	Glasen, Nils	AB.
20.	Winkler, Michael	AB.
21.	Schröder, Norbert	AB.
22.	Scheel, Sebastian	AB.
23.	Hartwig-Labahn, Andreas	AB.
24.	Kretzschmar, Uwe	AB.
25.	Müller, Steffen	AB.
26.	Brickmann, Peter	AB.
27.	Sedlak, Andreas	AB.
28.	Beth, Detlef	Storekeep.
29.	Plehn, Markus	Mot-man
30.	Klein, Gert	Mot-man
31.	Krösche, Eckard	Mot-man
32.	Dinse, Horst	Mot-man
33.	Watzel, Bernhard	Mot-man
34.	Meißner, Jörg	Cook
35.	Tupy, Mario	Cooksmate
36.	Möller, Wolfgang	Cooksmate
37.	Wartenberg, Irina	1.Stwdess

No.	Name	Rank
38.	Schwitzky-Schwarz, Carmen	Stwdss/KS
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40.	Duka, Maribei	2.Stwdess
41.	Chen, Tingdong	2.Steward
42.	Hu, Guo Yong	2.Steward
43.	Chen, Quan Lun	2.Steward
44.	Ruan, Hui Guang	Laundrym.