ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS103

Polarstern

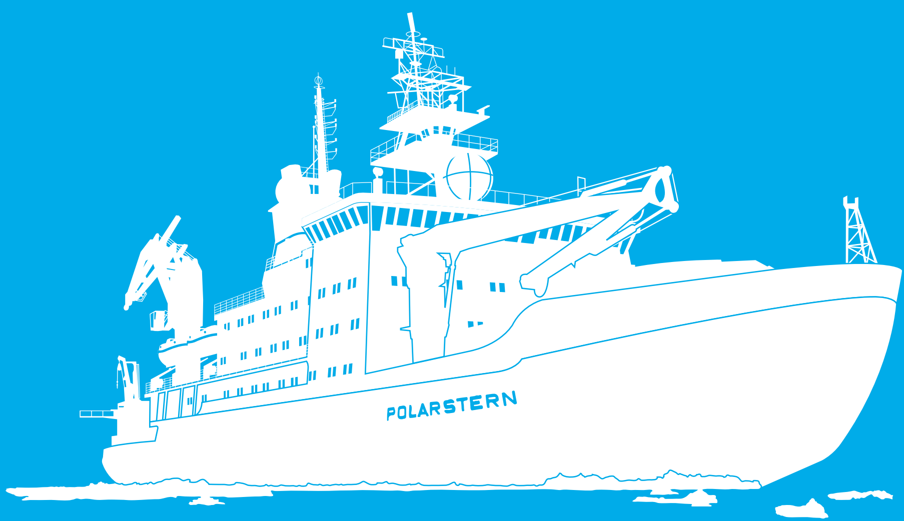
PS103

Cape Town - Punta Arenas

15 December 2016 - 3 February 2017

Coordinator: Rainer Knust

Chief Scientist: Olaf Boebel



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PS103

16 December 2016 - 3 February 2017

Cape Town - Punta Arenas

Chief Scientist

Olaf Boebel

Coordinator

Rainer Knust

Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Olaf Boebel (AWI)

Auf der *Polarstern* Expedition PS103 sollen Beiträge zu wissenschaftliche Projekten aus den Bereichen physikalische Ozeanographie, Meeresbiologie und Atmosphärenchemie gewonnen werden, die gemeinsam darauf abzielen, die Entwicklung der Wassermassen des Weddellmeers und seiner ökologischen und chemischen Kreisläufe zu verstehen. Zusätzlich zu diesen wissenschaftlichen Programmen werden mit der Versorgung der Neumayer Station die dort angesiedelten vielfachen wissenschaftlichen Aktivitäten und Projekte unterstützt. Die Projekte im Einzelnen sind:

- HAFOS (Hybrid Antarctic Float Observing System) untersucht die Zirkulation und Veränderung des Warmen Tiefwassers und des Weddellmeer Bodenwassers mit Hilfe von ozeanographischen Tiefseeverankerungen, hydrographischen Schnitten und meereistauglichen Tiefsee-Schwebesonden. Deren Auslage erweitert das internationale Argo Projekt auf die polaren Meere. Biologische Aspekte von HAFOS befassen sich mit der akustischen Ökologie des Weddellmeeres und seiner Fauna, wozu die Verankerungen um Unterwasserrekorder erweitert werden.
- Das Projekt „Sea Ice Mass and Energy Budget in the Weddell Sea“ installiert autonome Meereisbojen auf dem Meereis um die Massenbalance und Schneeakkumulation des Meereises im Weddellmeer zu bestimmen.
- INTERPELAGIC untersucht die trophischen Wechselwirkungen im Pelagial des südlichen Ozeans mit einem Fokus auf Hyperiide Flohkrebse (Amphipoden), Salpen und Krill. Es wird sowohl die Verbundenheit der Amphipodenpopulationen, als auch die Nahrungsbeziehung pelagischer Schlüsselarten anhand von Fraßgewohnheiten und Ernährung Hyperiider Amphipoden des südlichen Ozeans untersucht.
- ALGENOM sammelt lebende, fixierte und eingefrorene Planktonproben, um die Biogeografie, Diversität und Evolution von Diatomeen und anderen Phytoplankton-Organismen des Südozeans zu untersuchen.
- MicroPath untersucht einzelne und kombinierte Effekte von Temperatur, der Karbonat-Chemie des Meerwassers und der Zusammensetzung von organischem Material auf die heterotrophe Remineralisierung und die Bildung von bromierten Kohlenwasserstoffen in natürlichen Planktongemeinschaften des oberflächennahen Weddell Meeres.
- ISOTAM bestimmt das Verhältnis der stabilen $^{15}N/^{14}N$ Isotope in Luft- und Wasserproben, um Quellen marinen und kontinentalen Ammoniaks zu charakterisieren und um das Verhältnis der stabilen Stickstoff Isotope in Eisbohrkernen der Antarktis projizieren zu können.
- Das Project „Repeated GNSS measurements in the region of the Antarctic Peninsula to investigate neotectonics / Recovery of GNSS equipment from Gibbs Island“, hat zum Ziel eine auf Gibbs Island verbliebene GPS Station aufzunehmen.
- Das Projekt „Phytooptics“ beprobt kontinuierlich das Oberflächenwasser hinsichtlich optischer Eigenschaften und Pigmentkonzentrationen. Die gewonnenen biooptischen und biochemischen Daten unterstützen die Interpretation satellitengestützter, hyper- und multispektraler Ozeanfarbdaten.

Um diese Vorhaben umzusetzen wird das Forschungsschiff *Polarstern* am 16. Dezember 2016 von Kapstadt, Südafrika, aus zur Antarktisreise PS103 auslaufen. Auf süd-südwestlichem Kurs (s. Abbildung 1.1) beginnen mit Passieren der 12-Meilen Zone kontinuierliche Probennahmen des oberflächennahen Wassers zur Bestimmung seiner optischen Eigenschaften (Projekt Phytooptics). Diese werden für die Dauer der gesamten Expedition fortgeführt, ergänzt um weitere quasi-kontinuierliche Wasser- und Luftproben zur Bestimmung der Konzentration von atmosphärischem und im Oberflächenwasser gelöstem Ammoniak (NH3) und Ammonium (NH4+) für das Projekt ISOTAM.

Diese Arbeiten führen *Polarstern* zur Position 49°S 003°O, dem Ort der Auslegung eines ozeanographischen Bodendrucksensors der nun, nach 6 Jahren Auslegedauer, aufgenommen werden soll. Weiter Richtung Süd-Südwest steuernd und voraussichtlich bei 55°S die Meereisgrenze erreichend, sind zwischen 50°S und 60°S Netzfänge mit dem Bongo- und Multinetz geplant, um Mikrozooplankton Proben für die Projekte INTERPLAGIC und ALGENOM zu gewinnen.

Bei etwa 59°S werden wir den Greenwich (0°) Meridian erreichen um Kurs Süd, Richtung antarktischem Kontinent, zu nehmen. Entlang dieses Abschnittes sollen, im Rahmen von HAFOS, sechs ozeanographische Verankerungen aufgenommen und drei Verankerungen ausgelegt werden. Nahe jeder dieser und weiterer Verankerungspositionen wird der Kranzwasserschöpfer mit CTD (Leitfähigkeit, Temperatur- und Drucksonde) bis zum Boden gefiert um Wasserproben für biologische Untersuchungen (ALGENOM, MicroPath) sowie Salz- und Temperaturprofile zu gewinnen.

Anfang Januar 2017 sollten die Arbeiten auf dem 0°-Meridian abgeschlossen sein, worauf *Polarstern* Kurs West zur deutschen Neumayer-Station auf 70°40´S, 008°16´ W nimmt, um diese für die kommende Überwinterung mit Proviant und Treibstoff zu versorgen und die Reststoffe der vergangen Saison zu entsorgen.

Anschließend wird das Weddellmeer auf einem Zick-Zack Kurs bis hin zur Nordspitze der Antarktischen Halbinsel durchquert (s. Abbildung 1.1). Hierbei werden Argo Floats, frei schwebende ozeanographische Messsonden, ausgelegt, die eine flächige und mehrjährige Erfassung der Hydrographie des Weddellmeeres ermöglichen. Der Kursverlauf ist dabei durch die Lage von ozeanographischen Verankerungen des HAFOS Projektes vorgegeben. Diese Verankerungen, von denen zwölf aufgenommen und vierzehn ausgelegt werden sollen, tragen Strömungs-, Temperatur- und Leitfähigkeitsmessgeräte, Schallquellen zum Tracking der Argo Floats, sowie passiv akustische Rekorder.

Während auf den südlicheren Positionen der Weddellmeerquerung Meereisbojen unter anderem auch per Helikopter auf dem Meereis installiert werden sollen, planen wir auf dem nordwestlichen Segment über den Schelfabhang der Antarktischen Halbinsel hinweg die ozeanographischen Beprobungen mit Kranzwasserschöpfer/CTD und I-ADCP (lowered Acoustic Doppler Current Profiler) zu intensivieren, um den dortigen Ausstrom von Antarktischem Bodenwasser zu quantifizieren.

Nach Abschluss dieses hydrographischen Schnittes wird *Polarstern* Elephant Island anlaufen, um dort eine ozeanographische Verankerung auszulegen und die verbliebene GPS Station auf der nahegelegenen Gibbs Island abzubergen. Auf direktem Wege zu unserem Zielhafen Punta Arenas steuernd, werden weitere Netzhole mit dem Bongo- und Multinetz sowie Probennahmen mit dem Kranzwasserschöpfer im Bereich der Drake-Passage für die INTERPELAGIC und ALGENOM Projekte unserer Arbeitsprogramme abschließen. Der Anlauf unsers Zielhafens Punta Arenas ist für den 3. Februar 2017 vorgesehen.

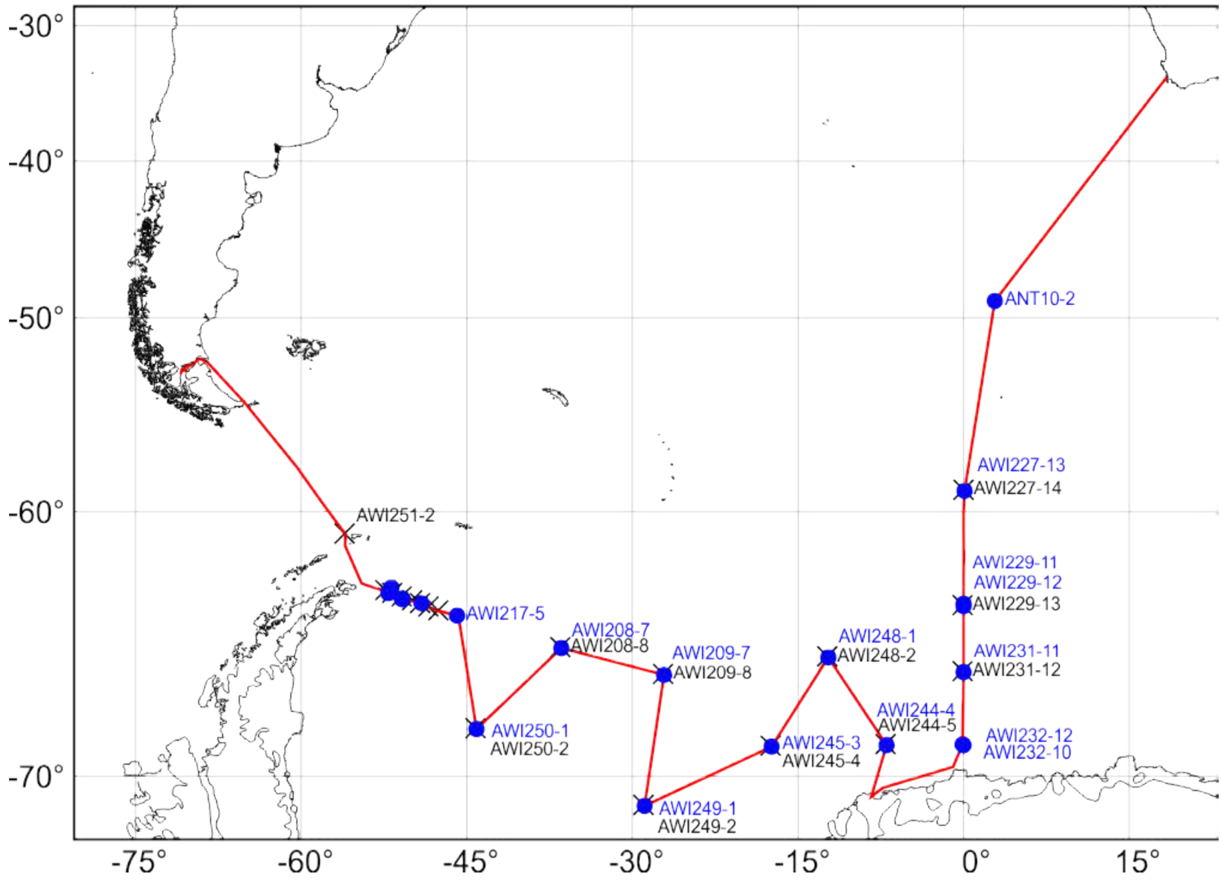

Abb.1.1: Karte des Untersuchungsgebietes und der geplanten Reiseroute der Polarstern Expedition PS103 (rote Linie). Blaue Punkte: Positionen aufzunehmender ozeanographischer Verankerungen. Schwarze Kreuze: Positionen auszulegender ozeanographischer Verankerungen. CTD Profile werden nahe der Verankerungspositionen gemessen werden. Netzfänge erfolgen entlang der Fahrtroute an geeigneten Orten.

Fig. 1.1: Chart of the study area and preliminary cruise track of Polarstern expedition PS103 (red line). Blue dots: Locations of oceanographic moorings to be recovered. Black crosses: Locations of oceanographic moorings to be deployed. CTD casts will be conducted near locations of all mooring operations. Net catches will be conducted in suitable locations along the cruise track.

SUMMARY AND ITINERARY

O. Boebel (AWI)

The focus of the *Polarstern* expedition PS103 is to provide contributions to scientific projects encompassing physical oceanography, marine biology and atmospheric sciences, with the general objective to improve our understanding of the evolution of the Weddell Sea water masses and the ecological and chemical cycles of the Weddell Sea. In addition to the direct scientific programme, this expedition also serves to resupply the German Neumayer Station, Antarctica to support their multifaceted scientific activities. Specific scientific projects conducted from aboard are:

- HAFOS (Hybrid Antarctic Float Observing System), which investigates the circulation and evolution of Warm Deep Water and Weddell Sea Bottom Water by means of oceanographic deep-sea moorings, hydrographic sections and autonomous floats, the latter of which also extent the international Argo Project to the polar seas. Biological aspects of HAFOS concern the acoustic ecology of the Weddell Sea and its fauna, for which moorings are equipped with autonomous recorders.
- The project „Sea Ice Mass and Energy Budget in the Weddell Sea“, which installs autonomous Sea Ice Buoys in the interior Weddell Sea's to acquire information of the sea ice mass-balance and snow accumulation.
- INTERPELAGIC, exploring the trophic interactions in the Southern Ocean pelagic realm with a focus on hyperiid amphipod crustaceans, krill and salps. Connectivity of amphipod populations will be investigated as well as the feeding interactions between the key pelagic players by exploring diet and feeding habits of hyperiid amphipod crustacean populations throughout the Southern Ocean.
- ALGENOM, collecting living, fixed and frozen plankton samples to explore the biogeography, diversity, and genomic and functional evolution in diatoms and other phytoplankton of the Southern Ocean.
- MicoPath, studying single and combined effects of temperature, seawater carbonate chemistry and organic matter composition on heterotrophic organic matter remineralization and the formation of bromocarbons in natural plankton communities of the surface Weddell Sea.
- ISOTAM, investigating the stable isotope ratio 15N/14N of ammonia and ammonium in air- and water samples to characterise atmospheric marine and continental ammonia sources and to project Nitrogen isotope ratios of NH4+ in Antarctic ice cores.
- The project „Repeated GNSS measurements in the region of the Antarctic Peninsula to investigate neotectonics / Recovery of GNSS equipment from Gibbs Island“, for which a GPS station shall be retrieved on Bibbs Island.
- The “Phytoptics” project, which continuously samples optical data and pigment concentrations of the surface water. These bio-optical and biochemical data aid the development of hyper- and multispectral ocean colour satellite retrievals focusing on fluorescence and absorption signals and serve for ocean colour data validation.

To carry out these projects, *Polarstern* will depart from Cape Town, South Africa, on 16 December 2016 for its expedition PS103. Following a south-southwestwardly course (Fig. 1.1), continuous water sampling will be started when leaving the territorial seas of South Africa to determine the optical properties of the surface water (project Phytooptics). Complemented by further quasi-continuous water- and air-sampling to determine the concentration of atmospheric and aquatic ammonia and ammonium for the ISOTAM project, these activities will be continuing throughout the entire expeditions.

These activities will take us to 49°S 003°W, where an oceanographic bottom pressure sensor shall be recovered which was deployed there 6 years ago. Continuing on a south-southwest ward route and reaching the sea ice edge at about 55°S, Bongo and Multinet hauls will be conducted between 50°S and 60°S to gather microzooplankton samples for the projects INTERPELAGIC and ALGENOM.

We will reach the Greenwich (0°-)meridian near 59°S, turning due South, towards Antarctica. Along this section, six oceanographic moorings shall be recovered for the HAFOS project while three will be deployed. Close to these and further mooring locations, the rosette water sampler and CTD (conductivity, temperature and depth sensor) will be lowered to the sea-floor to obtain water samples for biological studies (ALGENOM, MicroPath), temperature and salinity profiles.

Early January 2017, these activities will be completed and we will head westwards, calling port at Neumayer Station a few days later, to provide the German overwintering station with provisions and collect its waste.

Thereafter, research activities will be continued along a zigzag course across the Weddell Sea, towards the tip of the Antarctic Peninsula (Fig. 1.1). Along the track, we will deploy Argo floats, free floating oceanographic probes, which provide multi-year long, spatially spread under-ice observations of the Weddell Sea's hydrography. While crossing the Weddell Abyssal Plain, *Polarstern*'s course is governed by the position of the oceanographic deep-sea mooring of the HAFOS Project. These moorings, twelve of which will be recovered while fourteen will be deployed, feature current-, temperature-, and conductivity sensors, sound sources to track the Argo floats, as well as passive acoustic recorders.

At the more southward positions of our Weddell Sea crossing, sea ice mass buoys will be installed (also by helicopter) on the sea ice, while oceanographic sampling with rosette/CTD and l-ADCP (lowered Acoustic Doppler Current Profiler) will be intensified along its westernmost part, up the continental slope of the Antarctic Peninsula, to quantify the export of Antarctic Bottom Water there.

After completion of this section, *Polarstern* will head for Elephant Island, where we will deploy an oceanographic mooring and recover the remaining GPS station on close-by Gibbs Island. Heading directly towards our port of destination, Punta Arenas, a final set of Bongo and Multinet hauls along with rosette sampling for the INTERPELAGIC AND ALGENOM projects will conclude our work programme. The expedition is scheduled to end in Punta Arenas, Chile, on 3 February 2017.

2. SCIENTIFIC PROGRAMME

2.1 HAFOS: Maintaining the AWI's long term ocean observatory in the Weddell Sea

O. Boebel, J. Allerholt, M. Falla, R. Graupner, F. Hamm, H. Hampe, I. Ivanciu, K. Latarius, R. Mattmüller, M. Monsees, N. le Paih, G. Rohardt, M. Rücker van Caspel, S. Spiesecke, S. Tippenhauer, S. Zwicker (AWI)

Objectives

The ocean is a key element of the global climate system due to its ability to store and transport large amounts of heat, to act as a sink of carbon dioxide, and due to the sea ice ocean albedo effect. The response of the ocean to changes in the radiative and wind-driven forcing is controlled by its stratification as governed by the vertical structure of temperature and salinity. While until recently ship-borne observations provided the only means to obtain sufficiently accurate vertical profiles of water mass properties, during the last decade automated systems gained significantly in importance. The current backbone of the oceanic observing system is Argo, an internationally financed and organized array of >3,000 autonomous profiling floats with public, near-real time data access. However, in its current form, Argo is restricted to oceanic regions that are ice free year-round, as the floats need to surface regularly to be localized and to transmit their data. Furthermore, Argo does not access the deep ocean.

In an effort to overcome the observational constraints posed by high latitudes and the deep ocean, the Hybrid Antarctic Float Observing System (HAFOS) builds on vertically profiling, ice-resilient floats and a set of deep-sea moorings deployed throughout the Weddell Gyre to record oceanographic data at selected sites. HAFOS also includes an ecological component using passive hydroacoustic monitors (i.e. recording devices) embedded in each of the deep-sea mooring to collect data on the acoustic environment as shaped by manifold biotic and abiotic acoustic sources.

HAFOS was first established to its full extend in 2012/13 during *Polarstern* expedition ANT 29.2, yet subsets of the system existed in various configurations since 2002, allowing for the development and testing of components. The goal of this expedition is to service HAFOS by maintaining the mooring array and deploying additional ice-resilient floats.

Being the physical oceanography core project of this expedition, HAFOS intends to investigate the role of the Southern Ocean in the global climate system with focus on the Atlantic sector, including the Weddell Sea, where the densest bottom waters of the global oceans originate. The production of these dense water is controlled by the balance between:

- supplies of fresh water through precipitation,
- the melt of continental and sea ice,
- the extraction of freshwater by sea ice formation and evaporation, and
- a supply of warm and salty water masses as transported by the subpolar gyres towards the continental margins of Antarctica, with the gyres of the Weddell and Ross Seas being their most prominent expressions.

The basic mechanism of dense water generation involves upwelling of Circumpolar Deep Water, which is relatively warm and salty, into the surface layer where it comes into contact with the atmosphere and sea ice and becomes cooled and freshened. The newly formed bottom water is significantly colder and slightly fresher than the initial Circumpolar Deep Water, which indicates heat loss and the addition of freshwater. Since freshwater input in the upper oceanic layers would impede sinking due to increasing stratification of the water column, it has to be compensated by salt gain through fresh water extraction. Significant parts of salt accumulation occur on the Antarctic shelves in coastal polynyas. With extreme heat losses occurring over ice free water areas, the polynyas are areas of intense sea ice formation. Offshore winds compress the newly formed sea ice and keep an open sea surface in the polynyas.

The properties and volume of the newly formed bottom water underly significant variability on a wide range of time scales, which can only scarcely be explored due to the large efforts needed to obtain measurements in ice covered ocean areas. Seasonal variations of the upper ocean layers are only partially known and normally exceed other scales of variability in intensity. Impacts of longer term variations of the atmosphere-ice-ocean system, such as the Southern Hemispheric Annular Mode and the Antarctic Dipole, are only poorly monitored and understood. Their influence on or interaction with oceanic conditions are merely guessed on the basis of models which are only superficially validated due to lack of appropriate measurements.

This extreme regional and temporal variability represents a large source of uncertainty when data sets of different origin are combined. Therefore circumpolar data sets of sufficient spatial and temporal coverage are required and until recently could only be acquired for surface or integral properties by satellite remote sensing. However, to penetrate into the ocean interior and to validate the remotely sensed data, an ocean observing system is required, which combines remotely sensed data of sea ice and surface properties with long-term *in-situ* measurements of ocean interior properties, i.e. HAFOS.

Work at sea

The oceanographic studies during *Polarstern* cruise PS103 will concentrate on two major areas, the Greenwich Meridian and the Weddell Sea, continuing more than 30 years of *in-situ* observations in the Atlantic sector of the Southern Ocean. Employing moored instruments we seek to obtain time series of water mass properties throughout the deep and the surface layers. For this purpose, moorings featuring current meters, temperature and salinity sensors, sound sources and passive acoustic recorders, will be recovered and redeployed (Tables 2.1– 2.2). While, during the previous expeditions ANT-XXIX and ANT-XXX/2 (PS89), the recovery of moorings in ice covered areas was facilitated significantly using the ultra-short line positioning system (POSIDONIA), it nevertheless was not possible to retrieve 3 moorings due to extreme ice conditions. For this reason, special equipment (an ice drill, a ROV (remotely operated vehicle) and an ATV (all terrain vehicle) has been acquired and developed to recover moorings directly from the sea-ice and independent of the ship.

To enhance the vertical resolution and to calibrate moored sensors, CTD stations will be occupied at the mooring locations. The CTD/water sampler consists of a SBE911plus CTD system in combination with a carousel water sampler SBE32 with 24 12-l bottles. To determine the distance to the bottom, an altimeter from Benthos is mounted. A transmissometer from Wetlabs, a SBE43 oxygen sensor from Seabird Electronics and a fluorometer will be incorporated in the sensor package. Additionally, two RDI-150 kHz ADCPs, one pointing upward, one pointing downward are attached to the rosette sampler to measure the current velocity profile. The ADCPs occupies two bottle positions, thus only 22 bottles are available for water sampling.

To spread CTD observations horizontally, Argo compatible NEMO floats will be deployed enroute. The drift of these NEMO floats will distribute them to sampling sites across the Weddell Gyre. Moorings will contain sound sources, providing RAFOS signals for retrospective under-ice positioning of NEMO floats and passive acoustic recorders to record ambient (biotic and abiotic) sounds. During PS103, about a dozen NEMO floats will be deployed across the ACC throughout the Weddell Sea.

Tab. 2.1: Scientific instrumentation of planned moorings recoveries during PS103. Asterisks (*) indicate PIESs (bottom landers), rather than full moorings

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
ANT 10.2	49° 00.9274'S	4056	06.12.2010	DCS	31	4007
	02° 50.1722'E		03:58	PIES	250	4055
AWI227-13	59° 02.67' S	4600	13.12.2014	PAM	1056	1020
	00° 05.37' E		16:38	SBE37	8125	4557
AWI229-11	64° 00.31' S	5165	17.12.2014	AVTP	8395	202
	00° 00.22' W		11:43	SBE37	8129	203
				SBE37	9831	300
				SBE37	10943	400
				SBE37	10944	500
				SBE37	11419	600
				SBE37	11420	700
				RCM11	501	709
				PAM	1057	970
				SBE37	227	5121
AWI229-12	63° 54.94' S	5172	20.01.2015	SOSO	0048	798
	00° 00.16' E		11:38	PAM	1055	1001
				SBE37	228	5167
AWI231-11	66° 30.41' S	4472	19.12.2014	SOSO	0026	851
	00° 00.66' W		17:59	PAM	1058	973
				SBE37	11421	4429
AWI232-12	68° 58.89' S	3360	23.12.2014	AVT	8367	290
	00° 05.00' W		09:52	AVT	9211	798
				PAM	1059	999
				RCM11	472	1806
				SBE37	11422	3306
				RCM11	25	3307
AWI232-10(1)	69° 00.11' S	3370	19.12.2010	ULS	69	150
	00° 00.11' W		10:20	AVTP	8400	250
				AVT	9219	750
				PAM	1003	1250
				RCM11	212	1800
				PAM	403	2000
				SBE37	441	3300
				RCM11	216	3300
AWI244-4	69° 00.34' S	2900	16.01.2015	SOSO	0047	806

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
	06° 58.94' W		14:20	PAM	1061	998
				SBE37	12470	2857
AWI248-1	65° 58.09' S	5011	27.12.2012	SOSO	0028	839
	12° 15.12' W		08:50	PAM	1013	1081
				SBE37	9841	4968
AWI245-3	69° 03.47' S	4746	28.12.2012	SOSO	16	822
	17° 23.32' W		21:04	PAM	1012	1065
				SBE37	9839	4703
AWI249-1	70° 53.55' S	4364	30.12.2012	SOSO	0030	843
	28° 53.47' W		11:00	PAM	1014	1085
				SBE37	9847	4821
AWI209-7	66° 36.45' S	4830	01.01.2013	SBE16	2420	225
	27° 07.26' W		15:05	PAM	1027	226
				SOSO	0025	805
				PAM	1028	1007
				PAM	1029	2516
				SBE37	7728	4773
				SBE37	7729	4822
AWI243-1	68° 00.67' S	4443	31.01.2007	SOSO	31	800
	34° 00.15' W		06:15	SBE37	217	4436
AWI208-7	65° 37.23' S	4732	03.01.2013	SBE16	1167	300
	36° 25.32' W		13:4920	SOSO	0029	856
				SBE37	7730	4674
				SBE37	7731	4724
AWI250-1	68° 28.95' S	4100	05.01.2013	SOSO	23	798
	44° 06.67' W		14:53	PAM	1031	1041
				SBE37	9848	4057
AWI217-5	64° 22.94 S	4410	09.01.2013	SOSO	29/34	807
	45° 52.12' W		14:16	PAM	1020	960
				SBE37	9496	4316
				SBE37	9497	4366
				RCM11	135	4367
AWI216-5	63° 53.61' S	3513	11.01.2013	SBE37	9493	3356
	49° 05.17' W		00:17	SBE37	9494	3406
				SBE37	9495	3456
				RCM11	215	3457
AWI207-9	63° 43.57' S	2500	12.01.2013	PAM	1032	214
	50° 51.64' W		08:23	AVTP	11888	225
				SBE16	2413	253
				RCM11	474	756

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
				SOSO	27	807
				PAM	1033	1012
				SBE37	7732	2102
				SBE37	7733	2300
				RCM11	10530	2308
				SBE37	9492	2489
				PAM	1034	2491
				AVT	10498	2492
AWI207-8 (2)	63° 43.20' S	2500	06.01.2011	ULS	63	150
	50° 49.54' W		12:26	RCM11	294	250
				SBE37	1235	251
				AVT	8405	750
				SOSO	32	850
				PAM	845	2100
				SBE37	2235	2100
				SBE37	1605	2200
				RCM11	297	2300
				SBE37	1607	2490
				RCM11	311	2490
AWI206-7 (2)	63° 28.93' S	950	06.01.2011	ULS	65	150
	52° 05.87' W		20:52	AVTP	8417	250
				SBE37	2723	500
				RCM11	312	501
				SBE16	2418	700
				PAM	844	750
				SBE37	2097	900
				PAM	1006	910
				RCM11	313	912
AWI206-8	63° 15.51' S	917	14.01.2013	AVTP	11889	276
	51° 49.59' W		05:08	PAM	282LE	277
				SBE16	1975	499
				RCM11	508	500
				SBE16	1976	706
				PAM	0002	750
				SBE16	1977	908
				RCM11	100	909

Remarks:

(1) Mooring AWI232-10 was released during ANT-XXX/2 but *Posidonia* showed constant rather than decreasing transponder depth. Hooks of releasers deployed in 2010 have

repeatedly been blocked by residuals from anodes mounted close to the hook. This might be a possible explanation for the mooring's failure to surface.

(2) Moorings not recovered during ANT-XXIX/2. Localizing the releases with *Posidonia* was tried during PS96, however the releaser did not respond and no release command was issued.

Tab. 2.2: Scientific instrumentation of planned mooring deployments during PS103

Mooring ID	Latitude Longitude	Water Depth [m]	Instrument Type	Instrument Serial Number	Instrument depth [m]	Distance from bottom [m]
AWI227-14	59° 02.67' S	4600	PAM		1020	
	00° 05.37' E		SBE37		4557	
AWI229-13	64° 00.31' S	5165	AVTP		202	
	00° 00.22' W		SBE37		203	
			SBE37		300	
			SBE37		400	
			SBE37		500	
			SBE37		600	
			SBE37		700	
			RCM11		709	
			PAM		970	
			SBE37		5121	
AWI231-12	66° 30.41' S	4472	PAM		150	
	00° 00.66' W		PAM		500	
			PAM		800	
			PAM		1000	
			PAM		2000	
			SBE37		4429	
AWI244-5	69° 00.34' S	2900	SOSO		806	
	06° 58.94' W		PAM		998	
			SBE37		2857	
AWI248-2	65° 58.09' S	5011	SOSO		839	
	12° 15.12' W		PAM		1081	
			SBE37		4968	
AWI245-4	69° 03.47' S	4746	SOSO		822	
	17° 23.32' W		PAM		1065	
			SBE37		4703	
AWI249-2	70° 53.55' S	4364	SOSO		843	
	28° 53.47' W		PAM		1085	
			SBE37		4821	
AWI209-8	66° 36.45' S	4830	SOSO		805	

Mooring ID	Latitude Longitude	Water Depth [m]	Instrument Type	Instrument Serial Number	Instrument depth [m]	Distance from bottom [m]
	27° 07.26' W		PAM		1007	
			SBE37		4822	
AWI208-8	65° 37.23' S	4732	SOSO		856	
	36° 25.32' W		SBE37		4724	
AWI250-2	68° 28.95' S	4100	SOSO		798	
	44° 06.67' W		PAM		1041	
			SBE37		4057	
AWI257-1	64° 12.94' S	4170	SOSO		800	3370
	47° 29.40' W		SBE37		3970	200
			RCM11		4020	150
			SBE39		4040	130
			SBE37		4070	100
			SBE39		4100	70
			RCM11		4120	50
			SBE39		4130	40
			RCM11		4160	10
			SBE37		4160	10
AWI258-1	64° 03.99' S	3630	SBE37		3430	200
	48° 22.88' W		RCM11		3480	150
			SBE39		3500	130
			SBE37		3530	100
			SBE39		3560	70
			RCM11		3580	50
			SBE39		3590	40
			RCM11		3620	10
			SBE37		3620	10
AWI259-1	63° 55.85' S	3510	RCM11		3160	350
	49° 8.65' W		SBE37		3210	300
			SBE39		3260	250
			SBE39		3310	200
			SBE39		3360	150
			RCM11		3410	100
			SBE37		3410	100
			RCM11		3470	40
			SBE37		3500	10
AWI260-1	63° 48.76' S	2980	RCM11		2630	350
	49° 51.89' W		SBE37		2630	350

Mooring ID	Latitude Longitude	Water Depth [m]	Instrument Type	Instrument Serial Number	Instrument depth [m]	Distance from bottom [m]
			SBE39		2680	300
			SBE39		2730	250
			SBE39		2780	200
			RCM11		2830	150
			SBE37		2830	150
			RCM11		2940	40
			SBE37		2970	10
AWI207-10	63° 39.35’ S	2490	PAM		200	2290
	50° 48.62’ W		RCM11		250	2240
			SBE37		250	2240
			RCM11		750	1740
			SOSO		850	1640
			RCM11		2140	350
			SBE37		2140	350
			SBE39		2190	300
			SBE39		2240	250
			SBE39		2290	200
			RCM11		2340	150
			SBE39		2340	150
			RCM11		2450	40
			RAM		2480	10
			SBE37		2480	10
AWI261-1	63° 30.89’ S	1730	PAM		900	830
	51° 38.20’ W		RCM11		1380	350
			SBE37		1380	350
			SBE56		1430	300
			SBE56		1480	250
			SBE56		1530	200
			RCM11		1580	150
			SBE37		1580	150
			RCM11		1490	40
			SBE37		1720	10
AWI262-1	63° 24.20’ S	680	RCM11		330	350
	52° 17.21’ W		SBE37		380	300
			SBE56		430	250
			SBE56		505	175
			RCM11		530	150

Mooring ID	Latitude Longitude	Water Depth [m]	Instrument Type	Instrument Serial Number	Instrument depth [m]	Distance from bottom [m]
			SBE56		580	100
			SBE37		630	50
			RCM11		640	40
			SBE37		670	10
AWI251-2	61° 0.88' S	320	AZFP		200	
	55° 58.53' W		PAM		210	
			PAM		212	
			SBE16		316	

Abbreviations:

AVT	Aanderaa Current Meter with Temperature Sensor
AVTP	Aanderaa Current Meter with Temperature- and Pressure Sensor (mech.)
AZFP	Acoustic Zooplankton and Fish Profiler (acoust)
PAM	Passive Acoustic Monitor (Type: AURAL or SONOVAULT)
PIES	Pressure Inverted Echo Sounder
RCM11	Aanderaa Doppler Current Meter (acoust.)
SBE16	SeaBird Electronics Self Recording CTD to measure Temp., Cond. and Pressure
SBE37	SeaBird Electronics, Type: MicroCat, to measure Temperature and Conductivity
SOSO	RAFOS Sound Source
SBE56	SeaBird Electronics Temperature Logger
SBE39	SeaBird Electronics Temperature Logger
SMM	Subsurface Mooring Monitor (http://www.sis-germany.com/smm.htm)
ULS	Upward looking sonar from Christian Michelsen Research Inc. to measure the ice draft

Time permitting, a CTD/I-ADCP section shall be conducted between mooring 217-5 (near 45°E) and the tip of the Antarctic Peninsula (Fig. 2.1) aiming at delineating the export plume of Antarctic Bottom Water.

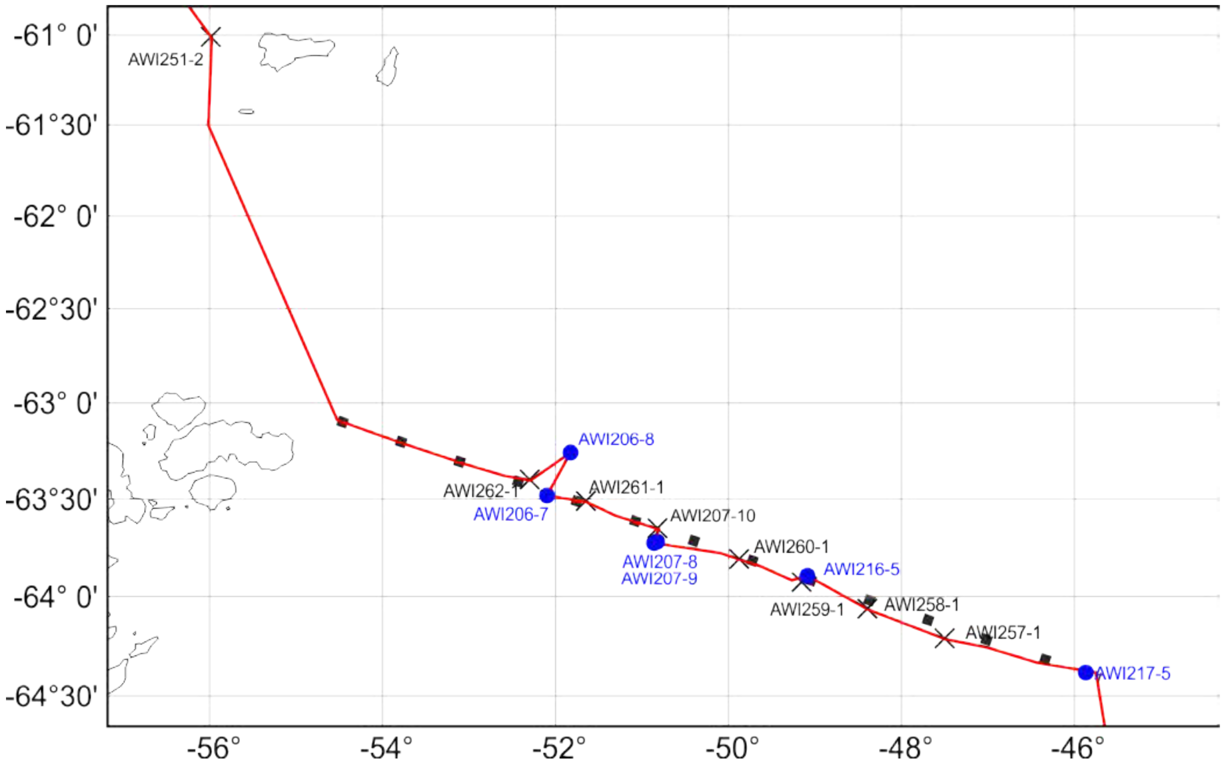

Fig. 2.1: Chart of the study area near the Antarctic Peninsula and cruise track of PS103 (red line). Blue dots: Locations of oceanographic moorings to be recovered. Black crosses: Locations of oceanographic moorings to be deployed. Black squares: Locations of CTD casts as planned.

Expected results

We expect to secure data from a large proportion of the instruments currently moored, together with ship-based CTD- and lowered ADCP data.

Data management

Metadata of recoded data will be made available through the cruise report. Mooring and CTD data will be made available after validation through the PANGAEA database. Float data will be made available through the Argo System. The processing of the lowered ADCP last several month but as soon as these data were processed and documented they will be available in PANGAEA too. Results will be published in international journals.

2.2 Sea ice mass and energy budgets in the Weddell Sea

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not on board: M. Nicolaus, L. Rossmann, S. Arndt (AWI)

Objectives

The sea ice physics programme during PS103 is mainly designed to renew the network of autonomous measurement platforms (buoys) in the Weddell Sea. Here, we continue and extend the successful deployments of buoys in the same region over the last two years (PS89 and PS96), as well as earlier programmes in the Weddell Sea. The main goal of these deployments is to obtain time series measurements of key parameters of the atmosphere, ice, ocean system, which are urgently needed for manifold projects. Based on the combined data sets from the many platforms, we aim to describe the state of sea ice coverage in the observation area. This will improve our knowledge concerning the determination of sea ice thicknesses from other methods like autonomous *in-situ* techniques or remote sensing products. Data that will be obtained during the cruise will additionally be used for the validation of sea ice and snow parameters derived from satellite data (e.g. CryoSat-2, SMOS, AMSR-E) and numerical models (e.g. FESOM), which in turn are used to identify the variability and trends in the sea ice cover. The deployments are a direct contribution to the International Program for Antarctic Buoys (IPAB).

Work at sea and expected results

We will deploy three different types of buoys on the sea ice. The buoys will be deployed in small arrays with distances of some 10 nm between the nodes. Since all buoys record and report their positions, the relative movement of the buoys allows additional analysis of dynamic sea ice processes, as ridging and lead opening. The deployment of all buoys will be performed either through direct access to the ice from *Polarstern* (gangway or mummy chair) or through helicopter transportation. The different buoy types are:

- Thermistor string buoys (ice mass-balance buoys, IMBs) will help to detect the temporal evolution of snow and sea ice thickness as they measure the sea ice surface and bottom accumulation and melt. Complementary, sensors allow for measurements of air, snow, and sea ice temperature.
- Snow Buoys will serve small-scale regional variability of snow accumulation. They measure snow depth, air temperature and barometric pressure.
- GPS buoys (surface velocity profilers, SVPs) in an array around the station, the evolution of sea ice and snow thickness can also be related to dynamical processes.

The most immediate results are high-resolution time series of essential climate variables from the autonomous measurements and thus directly contribute to various sea-ice related projects and research programmes. Further analysis will enable quantifications of energy and mass budgets of the Weddell Sea and thus help to improve satellite data interpretation and the improvement of numerical models, e.g. towards coupled bio-physical sea ice-ocean models.

Data management

All buoy data contribute to the International Programme on Antarctic Buoys (IPAB) and are available online in real time through www.meereisportal.de (and data.seaiceportal.de). Metadata of recoded data will be made available through the cruise report. All data will be published after processing in the pangaea.de database and publishing system. Final results and analyses will be published in international journals.

2.3 INTERPELAGIC: Interactions between key players of the Southern Ocean zooplankton: amphipods, copepods, krill and salps

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Objectives

The Southern Ocean is experiencing rapid climate change, particularly in the Southwest Atlantic sector. In this region, raising surface water temperatures and sea ice retreat have already resulted in density and distributional changes in the pelagic realm. Since the 1970s, Antarctic krill (*Euphausia superba*) has experienced a major decline, whilst salps (mainly *Salpa thompsoni*) are on the rise. This has traditionally been attributed to bottom-up factors such as alterations in summer phytoplankton blooms and winter sea-ice extent (Loeb et al. 1997, Atkinson et al. 2004). Salps indeed thrive in less productive and warmer waters, whilst

Antarctic krill is dependent on sea ice for feeding of the larvae during winter. Hence, salps may outcompete krill in a stressful environment (Pakhomov et al. 2002). A change from krill to salps would imply the substitution of a key component of the Antarctic food web with negative consequences for the higher trophic levels, such as the ice-associated and krill-feeding Antarctic blue and minke whales. Possibly this may also have biogeochemical implications with salp faecal pellets that are believed to enhance the sinking rate of biogenic carbon (Alcaraz et al. 2014).

However, these past and ongoing changes in krill and salp densities are not the only changes that the Antarctic and sub-Antarctic pelagial are likely to experience. Known as the most common pelagic amphipod in the Southern Ocean, the hyperiid *Themisto gaudichaudii* occurs in high densities in the neritic areas around sub-Antarctic and Antarctic islands, as well as in the oceanic zones around the Antarctic Polar Front. It also occurs along the Patagonian Shelf as well as in the Benguela Upwelling System, as far north as the Subtropical Front (Auel and Ekau 2009). Two bioregions have been identified, situated north and south of the Southern Antarctic Circumpolar Current Front (SACCF), influenced by the temperature and extent of the seasonal ice-zone. In the northern ice-free zones, more widespread species such as *T. gaudichaudii* dominate, whilst the southern region fauna, influenced by a seasonal sea ice cover, is composed of a more cold-adapted fauna such as Antarctic krill (Ward et al. 2012). Unlike krill, which is more closely associated with colder waters, *T. gaudichaudii* has a much broader temperature tolerance and hence may be better equipped to cope with change. In a current and predicted scenario of a decreasing winter sea-ice extent (e.g. Parkinson 2002), *T. gaudichaudii* could simply extend its range southward. Indeed, Mackey et al. (2012) predicted that, when considering pelagic species' distributions in relation to temperature, *T. gaudichaudii* will become much more widespread and abundant across the Atlantic sector of the Southern Ocean with a 1°C increase in winter water temperature. From present-day observations, one can already deduct the ramifications of these range shifts on the top predators of the Antarctic food web. Even though some krill consumers, such as macaroni penguins, can efficiently switch from a krill-based diet to an amphipod-based one in years of low krill availability, most species seem to be truly krill-dependent for their breeding success and even adult survival, such as black-browed and grey-headed albatrosses, Gentoo penguins and Antarctic fur seals (Croxall et al. 1999, Forcada et al. 2005).

Nonetheless, due to the knowledge gap on the role of top-down factors in the pelagial, in particular the interactions between the main pelagic species, ongoing changes in the Southern Ocean pelagic realm might remain unnoticed. Whilst Antarctic krill has been thoroughly studied, hyperiid amphipods have been neglected so far and their ecology is too little understood to make reliable predictions on possible distributional and ecological shifts. In order to foresee the consequences of these shifts, i.e. the poleward range expansion of *Themisto* and salps, and the range retraction of krill, their interactions need to be studied in terms of predation and competition for resources. With this project, we aim to gain a better understanding of the biology and ecology of *Themisto*, by studying its genetic and trophic connectivity. The feeding habits of *Themisto* have been studied only in a few localities (e.g. South Georgia, Pakhomov and Perissinotto 1996, Prince Edward Islands, Froneman et al. 2000). *Themisto* is believed, based on gut content analyses, to be an opportunistic predator feeding on a variety of mesozooplankton species, such as copepods, pteropods, chaetognaths, euphausiids and fish larvae, but recent studies pinpointed uncertainties regarding the prevalence of omnivorous feeding habits. Biomarker analyses revealed a rather high degree of herbivory (Stowasser et al. 2012). Feeding on phytoplankton has been hypothesized for juveniles based on gut contents (Pakhomov and Perissinotto 1996) and population dynamic analyses (Watts and Tarling 2012) but whether adults have similar habits should be further explored, bearing in mind a potential competition for food with krill and salps. The fact that *Themisto*'s feeding habits appear more complex than initially postulated and the lack of data hampering the characterisation of regional variation in its diet call for further studies with implications for the biological pump. Behavioural studies are required since it has not yet been explored how *Themisto* captures its prey. Due to its strikingly large compound eyes, *Themisto* has been hypothesized to be a voracious visual predator, but this is in contradiction with the fact that it migrates to the surface at dusk to feed and that it is capable of capturing copepods during imposed periods of darkness when kept in aquaria. Furthermore, it has been collected holding onto soft-bodied zooplankton (Laval 1980), however, the nature of these interactions (predatory vs. commensal) remained so far unexplained. Finally, genetic connectivity of *Themisto* populations has not yet been investigated with recent molecular tools or on a large geographical scale. Preliminary studies have pointed out the existence of three distinct genetic lineages within *T. gaudichaudii* in the Atlantic sector based on COI 'barcode' sequences (Havermans 2015), however, more specimens need to be investigated to test whether gene flow occurs between temperate, sub-Antarctic and Antarctic populations and between coastal and oceanic waters.

Hence, we aim to investigate during this expedition:

- The regional variation in diet between different populations of *T. gaudichaudii* throughout the Atlantic sector of the Southern Ocean (*light microscopy & molecular diet analyses*).
- the predatory interactions between the different Southern Ocean zooplankton components such as *Themisto,* copepods, euphausiids and salps by investigating *Themisto*'s food preference and feeding habits (*in vitro feeding experiments & behavioural observations*).
- the hypothesis of Themisto adults feeding on phytoplankton aggregates (in vitro feeding experiments and molecular/morphological gut content analyses).
- the genetic connectivity of *Themisto* throughout the Southern Ocean (*phylogeography*) and the extent of gene flow between different populations (*population genetics*).

Work at sea

Macrozooplankton samples will be collected by oblique trawling of Bongo nets; mesozooplankton samples by means of vertical hauls with a Multinet (Midi-MN). Water samples will also be taken using small buckets/bottles for growing phytoplankton aggregates in the laboratory. Samples will be sorted out and alive specimens kept in buckets with cold water supply before being transferred to the containers on board for the experiments. Of the remaining ones around 20 individuals will be preserved for molecular diet and population genetic analyses in ethanol and RNAlater (at -80°C) respectively, whilst 10 more will be frozen at -20°C for additional comparative biomarker analyses. Morphological gut content analyses can be initiated on board with the stereomicroscope. DNA extractions, amplification and sequencing will be carried out at the home laboratory.

Expected results

We expect to characterize the life history and population dynamics of hyperiid amphipod populations and compare them between the different sampling localities. Body size measurements will be taken for all collected specimens in order to determine life history characteristics of the different populations sampled. If enough amphipods are caught, results of the *in vitro* feeding experiments will elucidate possible feeding preferences for particular zooplankton prey and behavioural observations will shed light on the predator prey interactions that will be confirmed by molecular and morphological gut content analyses of the preserved animals. In the case of prey preference experiments, different sets of amphipods will be exposed to mixtures of different potential prey, or different life stages. Observations on feeding habits will be carried out by installing video recording devices and by direct observations of *Themisto* handling the prey. Finally, other data on the biology of the different zooplankton species will be collected by measuring swimming speeds of individual amphipods in large containers and sinking speeds of dead individuals and other zooplankton experimentally calculated.

Data management

Occurrence and abundance data will be made available through the cruise report and subsequently through scientific publications and the PANGAEA database. Genomic and genetic marker data (COI, 16S rRNA sequences) will be made publically available in GenBank upon publication in a scientific journal. Finally, results of the feeding experiments will be published in international journals.

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2.4 Algenom: molecular ecology of primary producers

B. Beszteri, F. Buttler, A. Fong (AWI)

not on board: K. Valentin, U. John, L. Friedrichs (AWI)

Objectives

Primary producers (microalgae) form the basis of food webs and are important drivers of the biological carbon and silicate pump in the Southern Ocean like in other oceans as well. Our working group will collect samples for different research projects addressing the diversity and ecology of these microscopic organisms in the pelagic of the Southern Ocean.

The aims of these projects are the following:

- Characterize the amount of neutral and adaptive genomic variation among populations of one of the best studied diatom species of the Southern Ocean, Fragilariopsis kerguelensis (O'Meara) Hustedt; get insights into microevolutionary dynamics and their relation to main environmental regimes (Antarctic Circumpolar Current [ACC] vs. Weddel Sea) and gradients (latitudinal gradient across the ACC and associated physico-chemical gradients) in this species. For this, clonal cultures will be isolated from 8-10 populations along the North-South transect from the Northern rim of the Antarctic Circumpolar Current into the Weddel Sea. These cultures will be transported to the home laboratory for population genomic and phenotypic characterization.
- Characterize the valve morphological responses of F. kerguelensis to the presence of grazers at the ecological and micro-evolutionary scale using a combination of experimental and in silico approaches. For this project, again, clonal diatom cultures, as well as living copepod grazers will be collected during the expedition and transported to the home laboratory for co-cultivation experiments.
- Get insight into community-wide gene expression patterns accompanying environmental gradients across the ACC in phytoplankton communities for the "Sea of Change" project

  (http://genome.jgi.doe.gov/SeaofArctiOcean/SeaofArctiOcean.info.html). This project addresses taxonomic and gene expression turnover in oceanic phytoplankton along temperature gradients in the Atlantic in both hemispheres. During this expedition, the Antarctic part of sampling for this project will be performed. Plankton (roughly corresponding to the nanoplankton-microplankton size range) will be sampled for extraction of nucleic acids and subjected to high throughput sequencing and bioinformatics analyses together with the already existing samples collected for this project.

Work at sea

Sampling for all three subprojects will be performed at 8-15 common stations by CTD casts with water collection at the depth of chlorophyll maximum, and phytoplankton and bongo nets. Samples will be subdivided and processed by a combination of methods. Seawater subsamples will be serially filtered onto 1.2 and 0.2 µm pore size membrane filters and frozen for later DNA and RNA extraction in the home laboratory. The nucleic acid samples will be used for marker gene amplification and sequencing for characterizing microbial (eukaryotic and prokaryotic fraction) community composition and its changes along the transect. Further subsamples will be filtered for measurement of contextual parameters including chlorophyll, inorganic nutrient, particulate organic carbon and biogenic silicate concentrations. A quantitative sample from a Niskin bottle, as well as a phytoplankton net sample, will be fixed with formaldehyde for light microscopic counting a microphytoplankton and for electron microscopic identification. To characterize patterns of intraspecific genomic variation in our target species Fragilariopsis kerguelensis, 30-50 clonal cultures from each population encountered will be isolated by picking single chains and repeatedly washing them in filtered seawater medium under the inverted microscope. After inoculation into an algal growth medium, the isolates will be grown in the laboratory container at near ambient temperatures and light-dark cycle. The isolates will be transported back to the home laboratory alive for experimental work and in depth genomic and population genomic characterization.

Data management

Measured physico-chemical parameters will be deposited in PANGAEA (www.pangaea.de). Permanent diatom slides and material will be deposited in the Hustedt Diatom Study Centre (herbarium code BRM). The main type of primary data to be obtained during the cruise is nucleotide sequence data which will be deposited in the corresponding databases of the International Nucleotide Sequence Database Cooperation (INSDC: http://www.insdc.org/).

2.5 MicroPath: Effects of environmental changes on microbial pathways relevant for the production of climate-active gases

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not on board: J. Piontek (GEOMAR)

Objectives

The exchange of climate-active gases between atmosphere and ocean is driven by physical, chemical and biological processes in the ocean. The Southern Ocean is a net sink for atmospheric CO_2 that is strongly controlled by biological processes (Orr et al., 2001; Takahashi et al., 2002). The biological drawdown of CO_2 in the ocean is mainly driven by phytoplankton primary production and the subsequent export of organic carbon towards long-term storage in the deep ocean. However, heterotrophic bacterial activity can remineralize about 50 % of primary production in surface waters of coastal and low-latitude oceans, thereby producing CO_2 that is released back to the atmosphere on short time scales (Robinson 2008). Hence, environmental changes that tip the balance between autotrophic CO_2 fixation and heterotrophic CO_2 production have a high potential to affect carbon budgets and the storage of CO_2 in marine systems. Temperature has a stronger impact on bacterial heterotrophic metabolism than on autotrophic CO_2 fixation, implying the decoupling of phytoplankton production and bacterial growth in cold oceans (Pomeroy and Deibel, 1986). An increasing number of studies revealed the high potential of temperature and organic matter for synergistic effects on bacterial activity in polar oceans (Kritzberg et al., 2010; Piontek et al., 2015). Temperature sensitivities of enzymatic degradation processes increase with increasing molecular complexity of substrates. Several studies in soil science show that the temperature sensitivity of bacterial litter degradation can be directly linked to the chemical complexity of the material (Fierer et al., 2005; Steinweg et al., 2013). Whether the structural complexity of substrates impacts the temperature sensitivity of bacterial organic matter turnover and, thereby, the biological CO_2 production in the ocean is currently unknown.

In addition to CO_2 production by heterotrophic bacteria, marine microbes also exert influence on the production of climate-active trace gases that play an important role for atmospheric composition and chemistry (Salawitch et al., 2005; Liss et al., 2007). The importance of halocarbons in the degradation of the stratospheric ozone layer is increasing as the anthropogenic emission of chloroflurocarbons is ceasing (Montzka & Reimann, 2011). Biological production of bromoform and dibromomethane is currently hypothesized as the main source for oceanic bromocarbons, but with little knowledge of the detailed mechanisms. The role of biological processes as a marine sink for bromoform and dibromomethane is still speculative. The ability of degrading halogenated organic compounds is well-known for different bacterial taxa (Fetzner, 1998; Damborsky, 1999). Therefore it is suggested that high bacterial activity and abundance would decrease halocarbon concentrations. In a recent study, a link between bromoform degradation and dibromomethane production was found (Hughes et al., 2013), as well as significant dibromomethane degradation in Antarctic diatom cultures. However, currently we lack even basic knowledge of how the gases are formed and destroyed in the surface oceans.

Results of this project will provide new rate estimates to evaluate and improve existing models. In the context of ocean change, this will help to improve our process understanding of climate feedback cycles.

Work at sea and expected results

The working programme in the Weddell Sea consists of three work packages (WP) consisting of field studies (WP 1) and on-board experiments (WP 2+3) The Weddell Sea is characterized by highly efficient remineralization of biogenic detritus, organic carbon, and opal, at shallow depth (above 200 m) (Usbeck et al., 2002). Previous microbiological studies revealed high shares of psychrotolerant bacterial isolates, suggesting a high responsiveness of bacterioplankton in the Weddell Sea to rising temperature (Delille, 1992, Helmke and Weyland, 1995). However, the temperature sensitivity of natural communities, its spatial variability and the potential of temperature effects to alter organic matter production and degradation has not been investigated so far.

WP 1: Field studies

The sampling stations in the Weddell Sea span an east-west transect that includes coastal as well as open ocean sites. Hence, gradients in phytoplankton production and ice coverage can be expected that provide the chance to sample for phyto- and bacterioplankton communities exposed to different supplies of organic matter. Sampling is planned for 10-17 stations, each with six depths from the surface to 100 m. Samples will be analyzed for rates of extracellular enzymes and bacterial abundances to characterize heterotrophic bacterial activity. Rate measurements will be combined with the analysis of carbohydrate- and protein-rich gel particles. At selected stations, also bromocarbons and organic matter will be analyzed.

WP 2: On-board experiments on temperature effects on hydrolytic extracellular enzymes

Rates of extracellular enzymes will be determined at *in-situ* temperature and at elevated temperature to estimate the activation energy (Ea) for enzymatic reactions driven by natural bacterioplankton communities of the Weddell Sea. Additionally, a series of incubations at each temperature will be amended with labile organic carbon to test combined effects of temperature and resources on bacterial activity. Organic matter amendment will be achieved by the addition of labile carbohydrates at defined concentrations. Experiments will be repeated at 5-10 stations to evaluate the natural variability of effect sizes.

WP 3: On-board experiments on halocarbon cycling

In order to elucidate the link between photosynthetic and bromocarbon production, seawater samples will be incubated in gas tight bottles under altered temperature conditions (4°C above *in-situ* temperature), as well as varying light intensities. Incubation studies will be started with surface seawater samples at four selected stations along the cruise track. Incubations will be run for up to 10 days with samplings every second day for microbial abundances, dissolved organic carbon (DOC) and oxygen concentrations. To test whether it is the reactive bromine or the organics which limits bromocarbon production and if this might change with future climate change, the yield of bromocarbons following bromoperoxidase additions will be measured. Microbial activity, bromocarbon concentrations and DOM composition will be determined at the beginning, in the middle and at the end of the incubation period. Oxygen evolution in the bottles will be measured to calculate net primary production rates. Biomass (calculated from cell abundances) and activity of phytoplankton and bacteria will be compared to bromocarbon and dissolved organic matter concentrations. The origin and lability of DOM will be estimated analyzing combined carbohydrate and amino acid composition. To differentiate between biological and chemical processes, abiotic controls will be included.

Results of *WP 1* will be used to calculate fluxes of sugars and amino acids driven by the hydrolytic activity of bacterial extracellular enzymes. Furthermore, attained depth profiles of enzyme activities and halocarbon concentrations will be compared to several physical parameters including oxygen, sea surface temperature and salinity. This will help to identify possible sources and processes related to halocarbon production and their oceanic emissions. Biogeochemical and microbiological profiles will be related to rates of halocarbon cycling attained in *WP3*. Results of *WP2* will increase the knowledge on temperature effects on heterotrophic bacterial organic matter degradation. Estimated activation energies for hydrolytic extracellular enzymes are useful to improve model projections on effects of warming in the Southern Ocean.

Data management

Samples collected during the cruise will be analysed at GEOMAR within about a year after the cruise. Publication in international journals is planned within two years after the cruise. Data will be made available to the public via PANGAEA after publishing.

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2.6 ISOTAM: Stable N - isotopes of ammonium and ammonia in and over the Atlantic Ocean

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Objectives

The ice shield of Antarctica is a huge archive for past global biogeochemical properties and earth system processes. Deposition rates of non-sea-salt-sulphate (NSSS), of non-continental nitrate and of ammonium in Antarctica do not seem to differ markedly in glacial and interglacial periods (Kaufmann et al. 2010, Legrand and Delmas 1988). The sources of the ionic constituents in polar firn and ice cores are, therefore, still a matter of debate. The atmosphere is an open system with global connections in space and time. The gateway from the lower latitudes of the Atlantic to Antarctica is, therefore, one special road of interest for understanding traits in Antarctic ice constituents and their relation to earth system processes.

Antarctic ice constituents could have their primary sources in the Southern Ocean and on continents (e.g. Duce et al. 2008). Sulphate, nitrate, ammonium and sodium are major targets of ice core analyses and their interpretations. The ∂ 34 S isotope ratio as tracer for sulphur in Antarctic and Greenland ice cores has been evaluated. (e. g. Delmas 1995). However N-isotopes of ammonium in ice cores are not measured yet. Especially the source of their ammonium is rather uncertain.

Ammonia gas (NH3) is the main alkaline gaseous compound in the atmosphere.It is the source of ammonium (NH4+) in atmospheric particles, droplets and ice cores. Ammonia is emitted into the atmosphere on a global scale mainly by volatilisation from liquid cattle waste. In the marine atmosphere NH3 could have its source in the ocean surface water (Bell 2006, Paulot et al. 2015). The concentrations of gaseous NH_3 and particulate NH_4^+ seem to drop by about one order of magnitude from the open ocean to the sea ice covered ocean (Ibrom et al 1991). NH_3 can flow between the atmosphere and the ocean in both directions (e.g. Schaefer et al. 1999, Paulot et al. 2015). The ocean was divided to be a sink in high and, therefore, cold latitudes and a source in low and, therefore, warm latitudes (Johnson et al 2008). Maritime airborne ammonium is mainly found in the nucleation and accumulation mode (e.g. Gravenhorst 1978, Gravenhorst et al. 1979, Schaefer et al 1993). Airborne NH_4^+ and non-sea-salt sulfate in remote areas frequently show molar ratios between 1 and 2 (e.g. Gravenhorst 1978, Paulot et al. 2015)). A reaction of acidic sulphate and alkaline ammonia seems to be realistic (Gravenhorst 1978, Johnson et al. 2008). NH_4^+ is produced within the ocean via N_2 fixation, ammonification of organic material, denitrification of nitrite and excretion by organisms and leaves the water via assimilation uptake, nitrification within the ocean, reaction of NH_4^+ with NO_2^- (anammox) and by emission of NH_3 into the atmosphere . The free NH_4^+ -N pool in the global ocean is only a small fraction (less than one permil) of the NO_3 –N pool. NH_4^+ sea water concentrations along a latitudinal transect across the Atlantic was around 10 to 250 µmol / m3 (Woodward 2006, Paulot et al. 2015).

∂ 15 N ratios of ammonia and ammonium in the atmosphere

Stable isotopes can indicate sources and transfer routes of atmospheric trace substances. Ratios of 15 N- NH_4 + and 15N- NH_3 isotope values in atmospheric samples are very rare. . The particulate ammonium in the atmosphere has a high ∂ 15 N value similar to the ∂ 15 N value of the NH_3-source material. The rain ∂ 15N-NH_4^+ value seems to fall between ∂ 15 N values for gaseous airborne NH_3 and for particulate airborne NH_4^+. All NH_3 and NH_4^+ and their isotopes in updrafts at cloud base will be incorporated into cloud droplets and subsequent into rain drops (Gravenhorst 1983).

15 N values of ammonia and ammonium in sea water

The N-cycle in the ocean is connected to the atmosphere (e.g. Duce 1986, Schaefer et al 1999) N-cycling has been characterized with ∂ 15 N values in different transformation processes (e.g. Sigman et al. 2009).

We want to measure actual concentrations of sea water NH_4^+ and NH_3 x H_2O and their 15N -isotope ratios (Woodward 2006, Watson et al. 2005) in comparison with atmospheric particulate NH_4^+ and gaseous NH_3. Cruise PS 103 traverses open water and sea ice covered regions. Oceanic flux of NH_3 from the ocean into the atmosphere or vice versa should therefore be strongly reduced. This should be reflected in atmospheric concentrations of NH_3, NH_4^+ and their isotope ratios.

Our aim is, therefore, to determine on the Northern and the Southern Atlantic from northern mid- latitudes to Antarctica the background pattern of the ratios of stable isotopes 15 N / 14 N of NH_4^+ and of NH_3 in the air and in the surface water to characterise possible sources of atmospheric NH_4^+ and their regional distribution. Our questions are:

1. What 15 N / 14 N-isotope ratios are found in ammonium of size separated airborne particles and in gaseous ammonia over the Atlantic?
2. What differences in NH_4 - and NH_3 - concentrations and in N - isotope ratios do exist between air over the North Atlantic, the South Atlantic and air over the ice- covered Atlantic?
3. Can we differentiate NH_3 -source and - sink regions on the Atlantic?
4. What finger prints do ammonia and ammonium, dissolved in the surface water of the Atlantic, leave in the atmosphere?

Work at sea and expected results

Concentrations of gaseous NH3 and particulate NH4+ in the lower atmosphere as well as physically dissolved NH3 x H2O and NH4 + in the surface sea water will be determined on the latitudinal transects of "RV *Polarstern* " from Bremerhaven to Filchner shelf ice and further Punta Arenas and back from Punta Arenas to Bremerhaven.

For NH3- and NH4+ concentration and δ 15N-NH3 and δ 15 N- NH4+ isotope measurements the NH4+ and NH3-gas molecules will be accumulated on filter pack systems (90 mm diameter). The filter pack system consists of one teflon-membrane filter in front to collect particles and three acidified membrane filters behind to absorb gas phase ammonia. Five individual standalone systems (filter pack, gas pump, gas meter, wind direction controller) will be installed on the deck above the bridge. For the case of wind blowing from the tail a similar filter pack system will be installed on the stern. Depending on the NH4+ mass found on each NH4 + - particle filter and on each NH3 ammonia filter the solutions of filters will used for NH4-N - and NH3-N isotope analyses on land according to Watson et al. 2005, Holmes et al. 1998.

Two identical high – volume samplers (ca 70 m 3 / h) will collect size-fractionated airborne particles with a 5 stage impactor. The 5 stages of the impactor (ca < 10 µm to > 0.1 µm radius) will be covered by a teflon foil and backed up with a teflon membrane filter (filter Ø = 20 cm, particle r < 0.1 µm radius). The impactors will be installed on the deck above the bridge. About 5,000 m^3 sample sizes (3 days of sampling) are necessary to collect enough NH4+- N , and SO4= - S for isotope analyses for the different particle seize ranges.

Data management

Samples of airborne particles and gases will be analysed chemically in home laboratories. Data will first be evaluated in bachelor and master theses. Concentrations and stable N-isotopes of these constituents will be discussed in a Polar Research report. Tabulated results will be submitted to PANGAEA. Results will be submitted to scientific journals for atmospheric and marine sciences.

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2.7 Repeated GNSS measurements in the region of the Antarctic Peninsula to investigate neotectonics / Recovery of GNSS equipment from Gibbs Island

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Objectives

The determination of the recent crustal motion pattern of Antarctica forms an important pre-condition for the investigation of its glacial history and of the tectonic situation. Changing ice-mass loads can be found in glacial history but also in recent times. The magnitude of these vertical deformations can be predicted on the basis of models which combine the glacial history with the viscoelastic reaction of the Earth. For West Antarctica these predictions cover a wide range, from 5 to more than 10 mm/yr, thus being much larger than predictions for East Antarctica. Different groups have made attempts to measure the vertical deformation by GNSS. Within the German Antarctic Project (GAP95 and GAP98) GPS stations were established and observed for the first time, among others, in the region of the Antarctic Peninsula, in 1995, 1996 and 1998. A consistent homogeneous reanalysis has been performed recently by Rülke et al (2015).

From repeated observations at selected GAP sites we will get vertical coordinate changes that serve to investigate the glacial isostatic adjustment (GIA). The vertical deformation rates will help to constrain GIA model predictions which still vary considerably among different models. Hence, the results will enhance the vertical deformation pattern yielded by observations in the Antarctic Peninsula region, and thus will allow to improve both the models on glacial history and on the viscoelastic response of the earth. Finally, an improved and more reliable determination of the GIA effect will have a positive feedback on estimates of the Antarctic ice-mass balance and of the respective sea-level change.

During *Polarstern* cruise PS97 (season 2015/2016) and in cooperation with Argentina we succeeded to install GNSS equipment at four sites (in the area of the Antarctic stations Arturo Prat (Chile), Esperanza and Marambio (Argentina), and at Gibbs Island). All equipment was recovered successfully except the one at Gibbs Island. Therefore, it is our goal to reach the site at Gibbs Island to end the observation and to recover the equipment.

Work at sea and expected results

Gibbs Island, belonging to the South Shetland Islands, is situated in the northern part of Bransfield Strait, south of Elephant Island. The location (61° 28' 51'' S, 55° 37' 53'' W) at Gibbs Island will be reached by helicopter. The equipment, consisting of GNSS receiver and antenna, solar panels and sealed battery, will be recovered and completely returned to *Polarstern*. Most likely, due to loss of electric power, the measurements will have to be halted. The data was recorded internally so that it can be recovered at the home institution.

The GNSS data will be analysed at home in a so-called post-processing. There are several reasons to do so. For example, for the analyses additional data have to be used which are provided only with some time lag after the observation time (such as precise orbit coordinates). Also, the geodetic GNSS analyses comprises all previous observation and a thorough realization of the (terrestrial) reference frame, for which data of external stations have to be incorporated (such as of the International GNSS Service). We will apply the scientific Bernese GNSS Software.

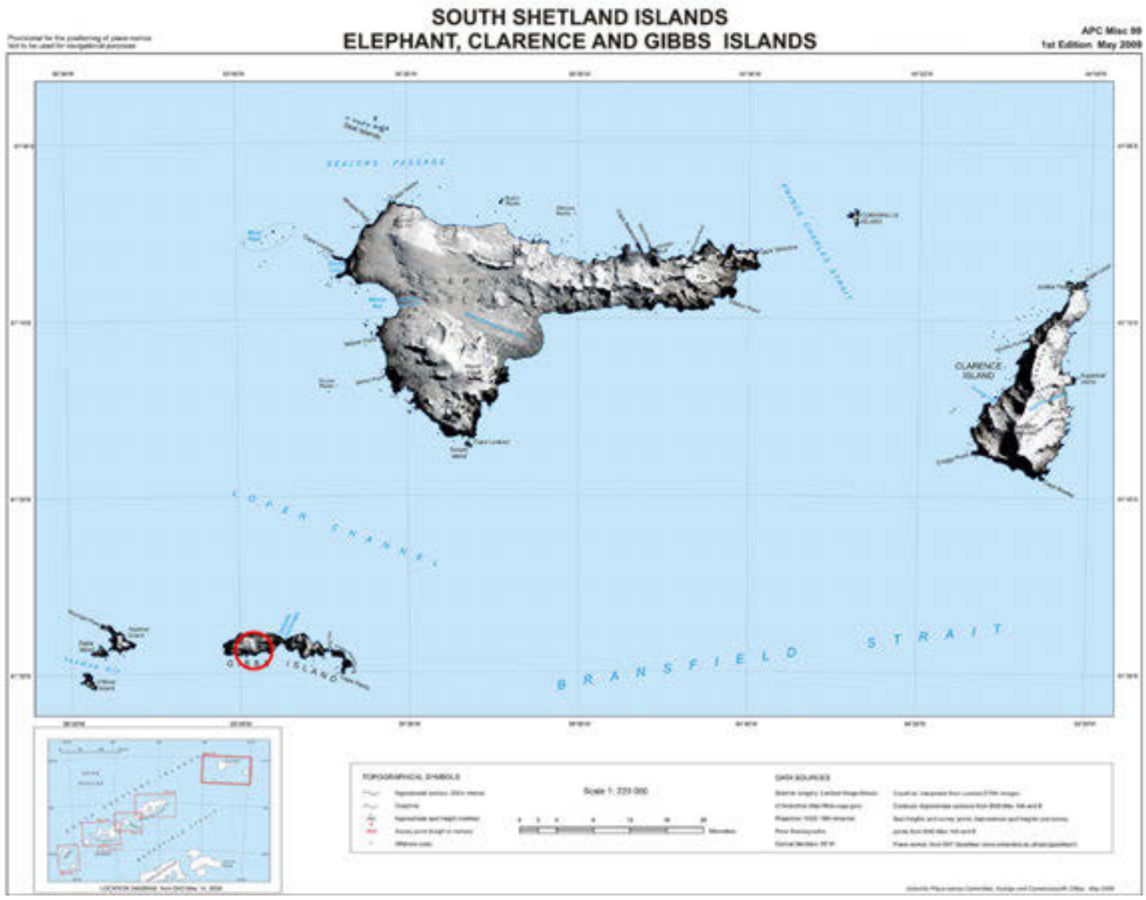

Fig. 2.2: Map of Elephant, Clarence und Gibbs Islands (© BAS Misc. Series, Sheet 99). The GNSS site is situated on Gibbs Island at 61° 28' 51" S 55° 37' 53" W.

Data management

All data will be archived in the framework of the SCAR GNSS Database which is maintained at TU Dresden as part of the SCAR Expert Group on Geodetic Infrastructure in Antarctica (GIANT).

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2.8 Phytooptics

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Objectives

The contribution of the Phytooptics group will be the measurement of biooptical properties and pigment composition, obtained continuously at the surface water but also at distinct stations in the water profile of the surface ocean. With that as much as possible collocated data to Sentinel-3 (launched in February 2016) ocean color sensor OLCI data shall be acquired for its validation, but (if launched until then) also for the data of the TROPOMI sensor on-board Sentinel-5 Precursor. (The Phytooptics groups is within the Sentinel-3 Validation Team). Continuous surface and profil biooptical data will be calibrated with geophysical data obtained from measurements at discrete water samples. Discrete water samples taken at surface every 3h and at CTD stations from 6 depths (down to max. 100 m) will be analysed to determine pigment concentration and composition, and CDOM (coloured dissolved organic matter), particle and phytoplankton absorption to finally determine from this the composition and amount of phytoplankton, other particles and CDOM.

Work at sea

Active and passive bio-optical measurements for the survey of the underwater light field, specific light attenuation, particle and phytoplankton composition and distribution shall be performed continuously on the surface water but also at CTD stations

- Continuous and discrete measurements of inherent optical properties (IOPs) with a hyperspectral spectrophotometer: For the continuous underway surface sampling an in-situ–spectrophotometer (AC-S; Wetlabs) will be operated in flow-through mode to obtain total and particulate matter attenuation and absorption of surface water. The instrument is mounted to a seawater supply taking surface ocean water. A flow-control with a time-programmed filter is mounted to the AC-s to allow alternating measurements of the total and the CDOM inherent optical properties of the sea water. Flow-control and debubbler-system ensure water flow through the instrument with no air bubbles. The AC-s needs to be operated on the seawater supply at the Nasslabor-1, with seawater pumped at Kastenkiel (in the bow of the ship) with the membrane pump- in order to deliver living phytoplankton cells continuously throughout the cruise, also within the ice, (except when based close to Neumayer to enable supply there or in polluted harbor stations).
- Discrete measurements of IOPS (absorption) at water samples are performed 1) for samples from the underway surface sampling (as for the AC-s flow-through system from the ship's sea water pump) at an interval of 3 hours, 2) for samples from the CTD station water sampling at 6 depths within the top 100 m. Water samples for CDOM absorption analysis are filtered through 0.2 µm filters and analyzed onboard with a 2.5-m path length liquid waveguide capillary cell system (LWCC, WPI).

Particulate and phytoplankton absorption coefficients are determined with the quantitative filter techniques using sample filtered onto glass-fiber filters QFT-ICAM and measuring them in a portable QFT integrating cavity setup Röttgers et al. (2015).

- Samples for determination of phytoplankton pigment concentrations and composition are taken at a 3-hourly interval from the underway-sampling system, and from 6 depths (max. 100 m) at CTD-stations. These water samples are filtered on board immediately after sampling and the filters are thermally shocked in liquid nitrogen. Samples are stored at -80°C until further analysis within the next three months by High Performance Liquid Chromatography Technique (HPLC) at AWI following Taylor et al. (2011).

Data management

Metadata (sample protocols of HPLC, absorption measurements and radiometer (RAMSES) and AC-s instrument operation time) of recorded data will be made available through the cruise report. The pigments will be measured after the cruise and the discrete sample absorption and pigment data and absorption, scattering and surface light data will be made available after validation through the PANGAEA database. Results will be published in international journals.

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10.	Buch, Erik-Torsten	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech
13.	Ganter, Armin	Electron.
14.	Markert, Winfried	Electron.
15.	Winter, Andreas	Electron.
16.	Feiertag, Thomas	Electron.
17.	Schröter, Rene	Boatsw.
18.	Neisner,Winfried	Carpenter
19.	Clasen, Nils	A.B.
20.	Schröder, Norbert	A.B.
21.	Burzan, Gerd-Ekkehard	A.B.
22.	Hartwig-Labahn, Andreas A.B.	
23.	Fölster, Michael	A.B.
24.	Müller, Steffen	A.B.
25.	Brickmann, Peter	A.B.
26.	Sedlak, Andreas	A.B.
27.	Schröder, Horst	A.B.
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	Cooksmat
36.	Möller, Wolfgang	Cooksmat
37.	Wartenberg, Irina	1.Stwdess
38.	Schwitzky-Schwarz,Carmen	Stwdss/KS
39.	Hischke, Peggy	2.Stwdess
40.	Grigull, Elke	2.Stwdess
41.	Krause, Tomasz	2.Steward
42.	Hu, Guo Yong	2.Steward
43.	Chen, Quan Lun	2.Steward
44.	Ruan, Hui Guang	Laundrym