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

EXPEDITION PROGRAMME PS117

Polarstern

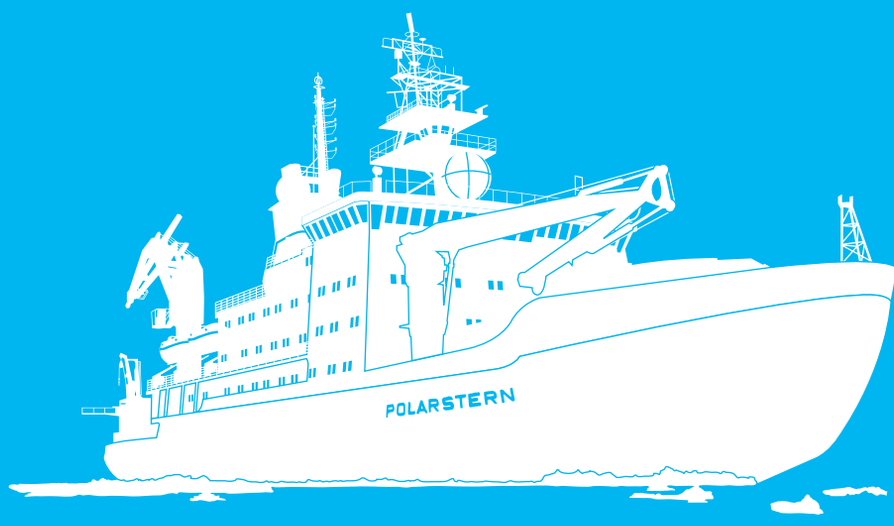
PS117

Cape Town - Punta Arenas

15 December 2018 - 7 February 2019

Coordinator: Rainer Knust

Chief Scientists: Olaf Boebel



Bremerhaven, November 2018

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CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Olaf Boebel (AWI)

Auf der *Polarstern* Expedition PS117 sollen Beiträge zu wissenschaftlichen Projekten aus den Bereichen physikalische Ozeanographie, Meeresbiologie und Meteorologie gewonnen werden, die gemeinsam darauf abzielen, die Entwicklung der Wassermassen des Weddellmeers und seiner ökologischen und chemischen Kreisläufe zu verstehen. Die Projekte im Einzelnen sind:

- **HAFOS** (Hybrid Antarctic Float Observing System) untersucht mittels ozeanographischer Tiefseeverankerungen, hydrographischen Schnitten und autonomen Floats die Zirkulation und Entwicklung des Warmen Tiefenwassers und Bodenwassers des Weddellmeeres. Biologische Aspekte von HAFOS betreffen die akustische Ökologie des Weddellmeeres und seiner Fauna, wofür Verankerungen mit autonomen Unterwasserrekordern ausgestattet werden.
- **FePhyrus** wird die Quellen und Senken von Spurenmetallen und Isotopen im Weddellmeer und der Lazarev See sowie die Wechselwirkung zwischen Eisen und dem mikrobiellen Nahrungsnetz untersuchen.
- **SOCCOM** (Southern Ocean Carbon and Climate Observations and Modelling) beobachtet und modelliert biogeochemische Kreisläufe des Südpolarmeeres mit dem Zweck Klimamodelle zu verbessern; die Beobachtungen werden mittels bio-geochemischer, profilierender Treibbojen durchgeführt, die über das gesamte Süd-polarmeer hinweg verteilt, ausgelegt werden.
- Im Projekt **Microplastics** wird das Vorkommen und die Verteilung von Mikroplastik im Wasser und den Lebewesen des Südlichen Ozeans untersucht.
- **SIPES 2 (Sea Ice Production and Ecology Study)** untersucht die Bedeutung des Meereises für pelagische Nahrungsnetze und für den Kohlenstoffffluss zu Toppredatoren (Seevögel und –Säugetiere).
- **ALGENOM-2** untersucht ökologische und evolutionäre Differenzierung entlang meridionalen Umweltgradienten im Südozean auf molekularer Ebene, in Gemeinschaften von einzelligen Eukaryoten sowie in ausgewählten Mikro-algentaxathe.
- Das Projekt **CombiBac** soll zu einem besseren Verständnis von Remineralisierungs-prozessen unter besonderer Berücksichtigung von Temperaturauswirkungen und Substratverfügbarkeit im Weddell Meer beitragen. Zu diesem Zweck werden Parameter der bakteriellen Aktivität, die Zusammensetzung der Bakterioplankton Gemeinschaft und Konzentrationen des organischen Materials in Feldproben und Experimenten an Bord bestimmt.
- Das Projekt "**Molecular ecology, physiology and life history tools to monitor the population of Dissostichus mawsoni over time and in relation to protection measures in the Weddell Sea**" zielt darauf ab, lebenden schwarzen Seehecht und weitere endemische Fischarten der Antarktis (Notothenioidei) mittels beköderter Reusenfallen zu fangen, um deren Physiologie, Genetik, Populationsstruktur und –dynamik näher zu untersuchen.

- Das Pilot-Vorhaben "**Einsatz von vertikalen Langleinen zur Erhaltung und nachhaltigen Bewirtschaftung des antarktischen Seehechts (Dissostichus mawsoni) im Weddellmeer unter CCAMLR**" testet einen neuartigen, gezielten Ansatz, um eine begrenzte Menge (max. 5 Tonnen) dieser Art für biologische, genomische und ökophysiologische Forschungen zu gewinnen.
- **YoPP AWImet-PS** wird, als Beitrag zum „Year of Polar Prediction“ (YOPP) die Häufigkeit von Radiosondenaufstiegen von Bord *Polarstern* von 1 auf 2 bis 4 pro Tag erhöhen.

Um diese Vorhaben umzusetzen wird das Forschungsschiff *Polarstern* am 15. Dezember 2018 von Kapstadt, Südafrika, aus zur Expedition PS117 auslaufen (Abbildung 1.1.). Diese führt durch den Südozean zur Antarktis und zurück, um am 7. Februar in Punta Arenas, Chile, zu enden. Kapstadt wird gegen Abend mit südwestlichem Kurs verlassen werden um wenige Tage später den Greenwich Meridian bei etwa 51°S zu erreichen. Diesem wird südlich bis zum Erreichen des Antarktischen Kontinents gefolgt und daraufhin der Atka Seaport angelaufen um kurz nach Jahreswechsel die deutsche Neumayer Station III zu versorgen. Hieran schließt sich eine Querung des Weddellmeeres im Zickzackkurs von Kaap Norvegia zur Nordspitze der Antarktischen Halbinsel an, bevor wir, die Elefanteninsel passierend, die Drakestraße queren, um über den östlichen Teil der Magellanstraße in Punta Arenas, Chile, als Zielhafen unserer Expedition am 7. Februar 2019 einzulaufen.

SUMMARY AND ITINERARY

Polarstern expedition PS117 focusses on providing contributions to scientific projects encompassing physical oceanography, marine biology and meteorology, with the general aim to better 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 immediate scientific program, this expedition also serves to resupply the German Neumayer Station, Antarctica to support the multifaceted scientific activities originating from there. Specific scientific projects conducted throughout the expedition from aboard are:

- **HAFOS** (Hybrid Antarctic Float Observing System), 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 extend 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.
- **FePhyrus** will investigate the sources and sinks of trace metals and isotopes in the Weddell Sea and Lazarev Sea and the interaction between iron and the microbial foodweb.
- **SOCCOM** (Southern Ocean Carbon and Climate Observations and Modelling) is observing and modelling the biogeochemical cycles of the Southern Ocean as a means of improving climate modelling; observations are made using biogeochemical profiling floats (BGC-Argo) that are being distributed throughout the Southern Ocean. UK **PICCOLO** (Processes Influencing Carbon Cycling: Observations of the Lower Limb of the Antarctic Overturning) scientists study the key processes controlling the rate of Southern Ocean carbon uptake, via the release of Argo floats and carbonate chemistry data collection on the Greenwich Meridian section in the Weddell Sea.

- The project **Microplastics** will explore the occurrence and distribution of microplastics in water and biota in the Southern Ocean.
- **SIPES 2 (Sea Ice Production and Ecology Study)** investigates the ecological importance of sea ice for the pelagic food web and carbon supply to top predators (birds and mammals).
- **ALGENOM-2** investigates the molecular evolutionary and ecological dynamics of unicellular eukaryotic assemblages and of selected taxa thereof.
- **CombiBac** aims for a better understanding of bacterial remineralization processes in the Weddell Sea with emphasis on their dependence on water temperature and substrate concentration. For this purpose, parameters of bacterial activity, the composition of bacterioplankton communities and concentrations of organic matter will be determined in field samples and during on-board experiments.
- The project "**Molecular ecology, physiology and life history tools to monitor the population of Dissostichus mawsoni over time and in relation to protection measures in the Weddell Sea**" aims at catching alive Antarctic toothfish and other endemic Notothenioids by means of baited traps to investigate their physiology, genetics, population structure and dynamics.
- The project "**Piloting vertical longlines in support of the conservation and sustainable management of Antarctic toothfish (Dissostichus mawsoni) in the Weddell Sea under CCAMLR**" explores a novel, targeted approach to catch a limited amount (max. 5 tonnes) of toothfish for biological, genomic and ecophysiological research.
- **YoPP AWImet-PS** will, as contribution to the „Year of Polar Prediction" (YOPP) increase the rate of radiosoundings on board *Polarstern* from 1 or 2 to 4 launches per day.

To realize these projects, the research vessel *Polarstern* will depart from Cape Town, South Africa, on 15 December 2018 for the expedition PS117 (Fig. 1.1), taking us across the Southern Ocean to Antarctica and back, to end on 7 February in Punta Arenas, Chile. Cape Town will be left in the evening on a southwesterly course, heading for the Greenwich Meridian which we will reach several days later at about 51°S. Sailing straight South until reaching the Antarctic continent, we will then veer west for the Atka Seaport to refurbish the German Antarctic Station *Neumayer III* shortly after New Year. Thereafter we will zig-zag across the Weddell Sea from Kaap Norvegia to the northern tip of Antarctic Peninsula, to finally cross Drake Passage and enter Magellan Strait to call port in Punta Arenas, Chile, the final destination of this expedition, on 7 February 2019.

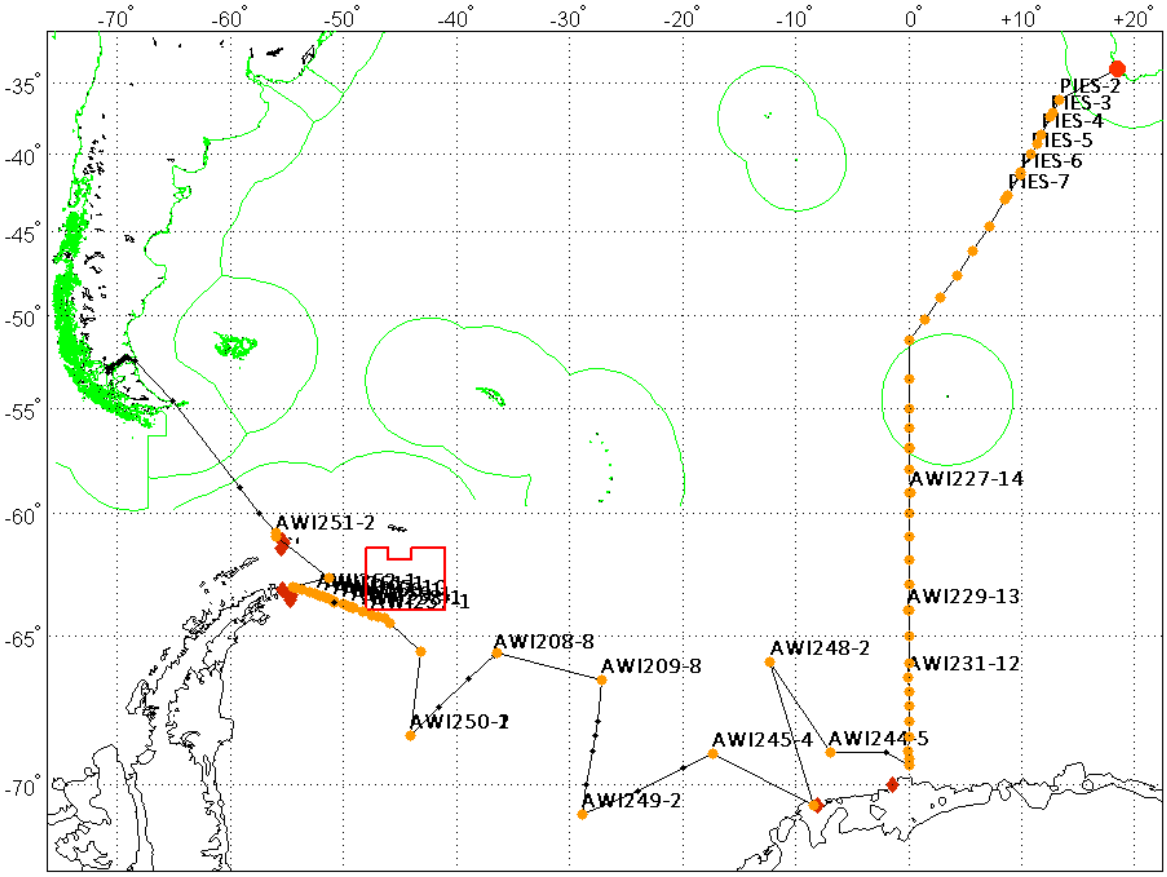

Abbildung 1.1: Karte des Untersuchungsgebietes und der geplanten Reiseroute der Polarstern Expedition PS117 (schwarze Linie). Benannte orange Punkte: Lokationen aufzunehmender oder auszulegender ozeanographischer Verankerungen. Sonstige orange Punkte: geplante CTD Stationen. Netzfänge erfolgen entlang der Fahrtroute an geeigneten Orten. Grüne Linien: Grenzen der EEZs. Rote Linien bzw. Rauten: CCMLAR Schutzgebiete und wichtige Vogelkolonien.

Fig. 1.1: Chart of the study area and preliminary expedition track of Polarstern expedition PS117 (black line). Named orange dots: Locations of oceanographic moorings to be recovered or deployed. Additional orange dots: planned CTD casts. Net catches will be conducted in suitable locations along the expedition track. Green lines: outer EEZ boundaries. Red lines and rhombs: CCMLAR protected area and important bird areas.

2. HAFOS: MAINTAINING THE AWI'S LONG TERM OCEAN OBSERVATORY IN THE WEDDELL SEA

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Grant No AWI_PS117_02

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 providing a positive feedback to sea ice melting. 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, automated systems gained importance during the last decade. 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, Argo is by and large 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, custom developed ice-resilient floats (Klatt et al. 2007) 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 recording devices embedded in each of the deep-sea moorings to collect data on the acoustic environment as shaped by manifold biotic and abiotic acoustic sources.

HAFOS was first established in its full extend in 2012/13 during *Polarstern* expedition ANT-XXVIIII/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 to allow localizing ice-resilient floats deployed in 2016/17 and in preparation for the deployment of additional ice-resilient floats next year, and to recover and continue the deep temperature und salinity long-term time series monitoring the state of Antarctic Bottom Water.

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 (Behrendt et al., 2011; Fahrbach, et al. 2011; Fahrbach et al., 2007). The production of these dense water is controlled by the balance between:

- supplies of fresh water through precipitation,
- the melting 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 (CDW), which is relatively warm and salty, into the surface layer where CDW comes into contact with the atmosphere and sea ice becoming cooled and freshened. The newly formed bottom water formed hereby 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 are subject to 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* expedition PS117 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-XXVIIII/2, ANT-XXX/2 (PS89) and PS103, 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 one mooring due to the 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 independently 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.

Moorings will contain sound sources, providing RAFOS signals for retrospective under-ice tracking of NEMO floats deployed during PS103 and passive acoustic recorders to record ambient (biotic and abiotic) sounds. During PS117, ten Argo floats will be deployed for the Bundesamt für Seeschifffahrt und Hydrographie (BSH) across the ACC throughout the Weddell Sea. Early in the expedition between Cape Town and 45°S, we will attempt to recover a set of 6 PIES (Pressure Inverted Echosounder) on behalf of our French colleagues from Ifremer. A CTD/l-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.

Tab. 2.1: Scientific instrumentation of planned moorings recoveries during PS117. 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)
PIES7	S 42° 41.647 E 08° 44.241	4970	28.07.2015 18:19	PIES	54	4970
PIES6	S 41°20.898 E 09°53.275	4680	27.07.2015 11:22	PIES	50	4680
PIES5	S 39°58.567 E 10°47.668	4775	07.12.2014 19:56	PIES	52	4775
PIES4	S 38°36.099 E 11°45.765	5120	07.12.2014 07:54	PIES	51	5120
PIES3	S 37°24.458 E 12°31.123	5070	25.07.2015 20:17	PIES	48	5070
PIES2	S 36°13.213 E 13°18.101	4832	06.12.2014 10:17	PIES	49	4832
AWI227-14	59° 03.03’ S	4641	24.12.2016	PAM	1004	1070
	00° 06.43’ E		16:15	SBE37	218	4597
AWI229-13	64° 00.49’ S	5197	26.12.2016	RCM11	296	202
	00° 00.84’ W		19:25	SBE37	1228	300
				SBE37	2089	400
				SBE37	2388	500
				SBE37	2389	600
				SBE37	8127	650
				SBE37	8128	700
				RCM11	461	709
				PAM	1053	993

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
				SBE37	233	5152
AWI231-12	66° 31.03' S	4577	28.12.2016	PAM	1021	223
	00° 04.49' W		15:24	PAM	1022	570
				PAM	1023	859
				PAM	1024	1064
				PAM	1026	2074
				SBE37	235	4535
AWI244-5	69° 00.32' S	2946	01.01.2017	SOSO	D0049	842
	06° 59.56' W		16:09	PAM	1057	1044
				SBE37	1232	2903
AWI248-2	65° 58.12' S	5047	01.01.2017	SOSO	D0024	833
	12° 13.87' W		16:56	PAM	1058	1035
				SBE37	1233	5003
AWI245-4	69° 03.64' S	4736	11.01.2017	SOSO	D0048	802
	17° 23.45' W		18:20	PAM	1005	1004
				SBE37	8130	4693
AWI249-2	70° 53.54' S	4401	13.01.2017	SOSO	D0028	837
	28° 53.47' W		16:32	PAM	1061	1041
				SBE37	8131	4357
AWI209-8	66° 36.45' S	4872	18.01.2017	SOSO	D0047	854
	27° 07.29' W		15:24	PAM	1008	1053
				SBE37	9487	4864
AWI208-8	65° 41.79' S	4766	19.01.2017	SOSO	D0030	830
	36° 41.01' W		22:15	PAM	1009	1032
				SBE37	9488	4758
AWI250-1*	68° 28.95' S	4100	05.01.2013	SOSO	23	798
	44° 06.67' W		16:00	PAM	1031	1041
				SBE37	9848	4057
AWI250-2	68° 27.84' S	4137	21.01.2017	SOSO	D0045	834
	44° 08.71' W		19:09	PAM	1003	1036
				SBE37	10931	4094
AWI257-1	64° 12.94' S	4293	23.01.2017	SOSO	D0026	803
	47° 29.42' W		17:23	SBE37	2234	200mab
				AVT	9768	150mab
				SBE39	7862	130mab
				SBE37	10948	100mab
				SBE39	7861	70mab

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
				AVT	9390	50mab
				SBE39	7860	40mab
				SBE37	10928	10mab
				AVT	9782	8mab
AWI258-1	64° 03.99' S	3933	24.01.2017	SBE37	9491	200mab
	48° 22.83' W		08:36	AVT	9187	150mab
				SBE39	7865	130mab
				SBE37	10939	100mab
				SBE39	7864	70mab
				AVT	9770	50mab
				SBE39	7863	40mab
				SBE37	10946	10mab
				AVT	9998	8mab
AWI259-1	63° 55.02' S	3449	24.01.2017	RCM11	506	350mab
	49° 16.09 W		15:35	SBE37	2090	300mab
				SBE39	7868	250mab
				SBE39	7867	200mab
				SBE39	7866	150mab
				RCM11	568	100mab
				SBE37	10929	99mab
				RCM11	500	40
				SBE37	2093	8mab
AWI260-1	63° 46.70' S	2819	25.01.2017	RCM11	462	350mab
	50° 05.38' W		08:39	SBE37	9832	300mab
				SBE39	7871	250mab
				SBE39	7870	200mab
				SBE39	7869	150mab
				RCM11	486	100mab
				SBE37	2092	99mab
				RCM11	504	40
				SBE37	2101	8mab
AWI207-10	63° 39.36' S	2555	26.01.2017	AVT	11613	305
	50° 48.68' W		10:27	SBE37	10930	318
				RCM11	569	808
				SOSO	D0048	959
				PAM	1029	1061
				RCM11	619	356mab
				SBE37	10947	355mab

Mooring	Latitude Longitude	Water Depth (m)	Date Time	Instrument Type	Instrument Serial Number	Instrument Depth (m)
				SBE39	7877	300mab
				SBE39	7876	250mab
				SBE39	7872	200mab
				AVT	10503	150mab
				SBE37	2395	149mab
				AVT	8037	40mab
				SBE37	10941	10mab
AWI261-1	63° 30.87' S	1700	26.01.2017	PAM	1011	842
	51° 38.14' W		18:55	AVT	9783	352mab
				SBE37	1234	350mab
				SBE56	6988	300mab
				SBE56	6987	250mab
				SBE56	6986	200mab
				AVT	9786	150mab
				SBE37	9490	149mab
				AVT	9997	40mab
				SBE37	10938	8mab
AWI262-1	63° 24.20' S	672	28.01.2017	AVT	8048	350mab
	52° 17.22' W		09:44	SBE37	10933	300mab
				SBE56	6991	250mab
				SBE56	6990	175mab
				AVT	8402	150mab
				SBE56	6989	100mab
				SBE37	10935	50mab
				AVT	8403	40mab
				SBE37	10936	8mab
AWI251-2	61° 01.26' S	331	29.01.2017	PAM	1031	215
	55° 58.84' W		15:36	PAM	AU0231	220
				SBE37	3814	319

***)** Recovery failed during expedition PS103 on January 21st 2017.

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.)
SBE37	SeaBird Electronics, Type: MicroCat, to measure Temperature and Conduct.

SBE39	SeaBird Electronics Temperature Logger
SBE56	SeaBird Electronics Temperature Logger
SOSO	RAFOS Sound Source
SMM	Subsurface Mooring Monitor (http://www.sis-germany.com/smm.htm)
ULS	Upward looking sonar (Christian Michelsen Res. Inc.) to measure the ice draft
AquaD	Nortek Aquadopp Acoustic Current Meter
QM150	RD Instruments Doppler Current Profiler, Typ Quarter Master 150 kHz
mab	Depth of instruments given in meters above bottom

Tab. 2.2: Scientific instrumentation of planned mooring deployments during PS117

Mooring	**Latitude Longitude**	**Water Depth (m)**	**Instrument Type**	**Instrument Depth (m)**
AWI227-15	59° 03.03’ S	4641	PAM	300
			AT	301
	00° 06.43’ E		SBE37	4597
			DAR	4599
AWI229-14	64° 00.49’ S	5197	SBE37	50
	00° 00.84’ W		SBE37	100
			SBE37	150
			AquaD	230
			SBE37	231
			PAM	300
			AT	301
			SBE37	330
			SBE37	430
			SBE37	530
			SBE37	630
			SBE37	734
			AquaD	735
			SBE37	5152
			DAR	5153
AWI231-13	66° 31.03’ S	4577	PAM	300
	00° 04.49’ W		AT	301
			SBE37	4534
			DAR	4535
AWI244-6	69° 00.32’ S	2946	PAM	300
	06° 59.56’ W		AT	301
			SBE37	2903
			DAR	2904
AWI248-3	65° 58.12’ S	5047	PAM	300
	12° 13.87’ W		AT	301

Mooring	Latitude Longitude	Water Depth (m)	Instrument Type	Instrument Depth (m)
			SBE37	5003
			DAR	5005
AWI245-5	69° 03.64’ S	4736	PAM	300
	17° 23.45’ W		AT	301
			SBE37	4693
			DAR	4694
AWI249-3	70° 53.54’ S	4401	PAM	300
	28° 53.47’ W		AT	301
			SBE37	4357
			DAR	4358
AWI209-9	66° 36.45’ S	4872	PAM	300
	27° 07.29’ W		AT	301
			SBE37	4864
			DAR	4865
AWI208-9	65° 41.79’ S	4766	PAM	300
	36° 41.01’ W		AT	301
			SOSO	803
			AquaD	806
			SBE37	807
			SBE37	4758
			DAR	4759
AWI250-3	68° 27.84’ S	4137	PAM	300
	44° 08.71’ W		AT	301
			SOSO	816
			AquaD	819
			SBE37	820
			SBE37	4094
			DAR	4095
AWI257-2	64° 12.94’ S	4293	PAM	300
	47° 29.42’ W		AT	301
			SOSO	810
			AquaD	813
			SBE37	814
			SBE37	4285
			DAR	4286
AWI207-11	63° 39.36’ S	2555	SBE37	250
	50° 48.68’ W		AT	292
			AT	293
			QM150	291
			PAM	300

Mooring	Latitude Longitude	Water Depth (m)	Instrument Type	Instrument Depth (m)
			SOSO	800
			AquaD	802
			SBE37	803
			SBE37	2200
			QM150	2248
			SBE39	2259
			SBE39	2305
			SBE39	2355
			SBE37	2406
			AVT	2516
			SBE37	2545
			DAR	2547
AWI251-3	61° 01.26' S	300	PAM	185
	55° 58.84' W		PAM	187
			SBE37	280
			AZFP	281
			DAR	297

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.)
SBE37	SeaBird Electronics, Type: MicroCat, (Temperature and Conductivity)
SBE39	SeaBird Electronics Temperature Logger
SBE56	SeaBird Electronics Temperature Logger
SOSO	RAFOS Sound Source
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
AquaD	Nortek Aquadopp Acoustic Current Meter
QM150	RD Instruments Doppler Current Profiler, Typ Quarter Master 150 kHz
AT	Acoustic Transponder Type ET801, ET861, ET862
DAR	Double Acoustic Releaser Typ RT2500, AR661, RT161,EG&G 8201
mab	Depth of instruments given in meters above bottom

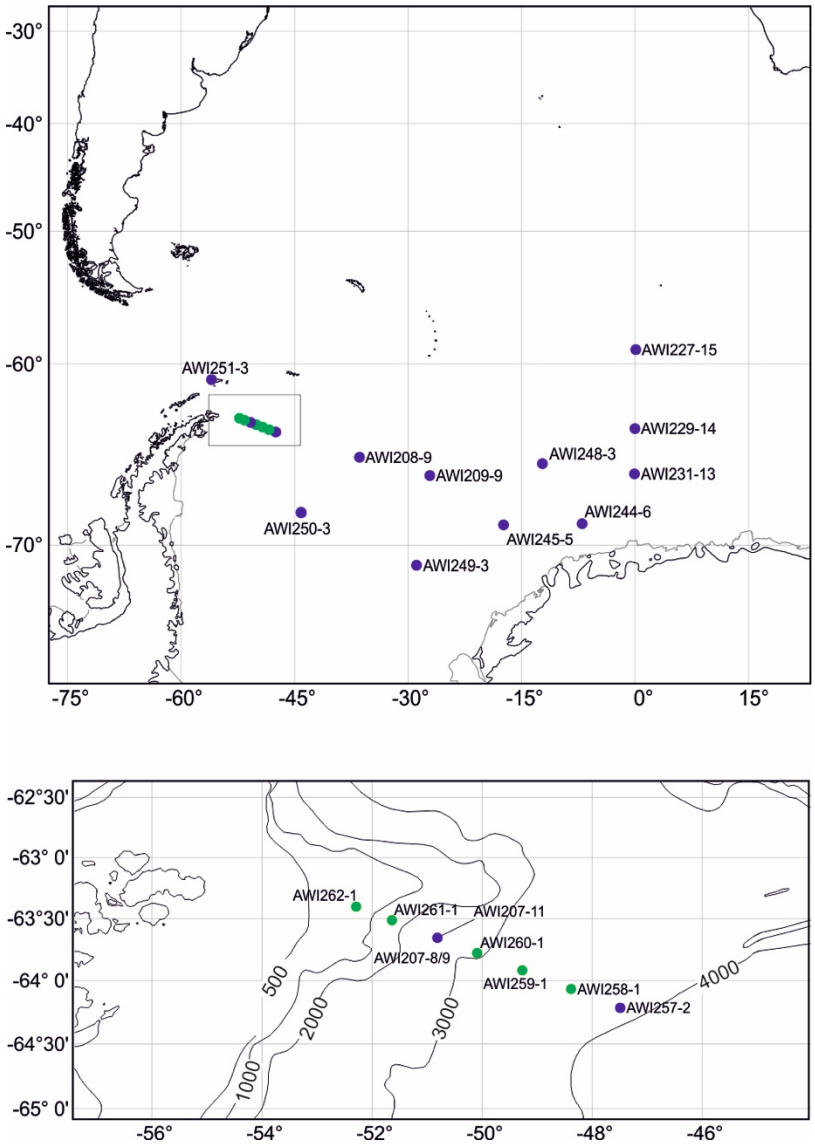

Fig. 2.1: Chart of the study area and zoom-in on area near Antarctic Peninsula. Blue dots: Locations of oceanographic moorings to be recovered and redeployed. Green dots: Mooring to be recovered.

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 policy

Metadata of recoded data will be made available through the expedition 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 and PANGAEA (Reeve et al., 2016). The processing of the lowered ADCP will 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.

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3. IRON (FE) LIMITATION AND VIRUSES, PHYTOPLANKTON CAUGHT BETWEEN A ROCK AND A HARD PLACE; FEPHYRUS

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Grant No AWI_PS117_03

Outline

The production of oceanic phytoplankton, which forms the base of the marine food web, depends on the availability of sunlight and nutrients, typically nitrogen and phosphorus (and silicate for diatoms). The Southern Ocean, however, is an important high nutrient low chlorophyll (HNLC) area (Bruland et al., 2014; Moore et al., 2013), where iron (Fe) affects the amount of atmospheric CO_2 sequestered in deep ocean waters and ocean sediments via the biological pump (De La Rocha, 2007), with far reaching implications for global climate and the local ecosystem (Arrigo et al., 2008; Boyd and Ellwood, 2010; Moore et al., 2013). Yet, it is becoming increasingly clear that the situation is more complex, and controlled by factors beyond just the scarcity of Fe. New insights highlight the importance of other trace-metals (Morel et al., 2014), co-limitation by two or more nutrients (Arrigo, 2005; Middag et al., 2013; Middag et al., 2011; Saito et al., 2008) and variability in nutrient requirements between species and environmental conditions (Arrigo and van Dijken, 2003; Klunder et al., 2014; Moore et al., 2013). Notably for Fe, its solubility and probably also its availability depends strongly on the Fe-binding dissolved organic ligands (Boye et al., 2005; Croot et al., 2004; Hassler et al., 2011; Maldonado et al., 2005; Thuroczy et al., 2010). Microbial community composition as well as microbial and viral interactions impact the production and cycling of metals and metal-binding ligands (Bonnain et al., 2016; Slagter et al., 2016).

Viruses are found in high numbers in the world's oceans, including polar seas (Evans and Brussaard, 2012; Marchant et al., 2000). They infect mostly the numerically dominant microorganisms (bacteria and phytoplankton). Viral activity results in lysis of the algal host cells, thereby converting particulate organic carbon into dissolved and colloidal organic carbon (Brussaard et al., 2008; Lønborg et al., 2013). Through cell lysis of the host, viruses do not only affect host community composition and the flow of energy and matter away from higher trophic levels, but also play a crucial role in nutrient cycling in general (Gobler et al., 1997; Wilhelm and Suttle, 1999). Viral activity seems to play a key role in recycling organically complexed Fe (Mioni et al., 2005; Poorvin et al., 2004; Poorvin et al., 2011). Virally-induced mortality rates of phytoplankton can be measured in the field concomitantly with grazing rates, allowing optimal interpretation of the absolute and relative importance of viral lysis (Mojica et al., 2016). In a recent study, viral lysis rates of different phytoplankton groups have been found to be equally sensitive to viral infection and cell lysis as to grazing (Mojica et al., 2016). Viral lysis of Antarctic microbes contributes to the dissolved organic matter pool (Brum et al., 2016; Evans and Brussaard, 2012), thereby serving a key role in the production of ligands. However, the role of viral lysis in driving Fe bioavailability remains poorly constrained, and the impact of global change on these processes remains difficult to predict.

The Antarctic undergoes rapid changes in physiochemical variables due to global climate change, including warming and altered Fe input (Alderkamp et al., 2012; De Jong et al., 2015; Gerringa et al., 2012; Joughin et al., 2014; Rignot et al., 2014). This will reflect in a changing phytoplankton community as not all phytoplankton species are equally sensitive to change or able to withstand changing conditions (Alderkamp et al., 2012; Arrigo, 2005; Arrigo et al., 2012; Mills et al., 2012). Additionally, the metal requirements change depending on the environmental conditions. For example, a reduction in Fe demand at higher temperatures (Sunda and Huntsman, 2011) could be explained by higher specific activity of major Fe-containing enzymes at elevated temperatures (John et al., 2002). If the response to Fe addition is not independent of temperature this could have significant implications for future projections of primary productivity in the face of global change, as current modelling assumes changes in Fe and temperature independently, not interactively, alter phytoplankton growth (Laufkötter et al., 2015).

Currently, much is still unknown about the sources of Fe and other bio-active metals to the Antarctic ecosystem. Antarctic glaciers and ice sheets are a relatively unquantified source of Fe and other metals that can fuel phytoplankton blooms (De Jong et al., 2015; Gerringa et al., 2012; Wadham et al., 2013). These glaciers and ice sheets are rapidly melting (Joughin et al., 2014; Rignot et al., 2014), potentially increasing this source (Alderkamp et al., 2012). Furthermore, little is known about the spatial extent of Fe fertilisation via Antarctic ice or the delivery of other metals from this source as the largest fraction of metals is delivered in the particulate phase and will quickly settle to the seafloor unless it can be solubilised and stabilised by organic ligands (Buck and Bruland, 2007). Moreover, other sources such as upwelling and the continental margin cannot be ignored either (De Jong et al., 2015; Gerringa et al., 2015; Middag et al., 2013; Middag et al., 2012). After entry and solubilisation into the ocean, the fate of Fe depends on the presence of ligands and the cycling through the microbial community and we are only just starting to understand how the cycling of Fe is affected by microbial actions, and in turn affects phytoplankton growth. Thus a closer look at sources of Fe, Fe-binding ligands and the interaction with the microbial community under changing conditions is critical.

Objectives

In awareness of the importance of (i) Fe as limiting nutrient for primary production in the Southern Ocean, (ii) ligands for increased availability of Fe for phytoplankton, and (iii) viral lysis as source of ligands, we propose to take a thus far rare synergetic approach by combining different disciplines to correlate composition, activity and losses of the phytoplankton

community with Fe and ligand concentrations along a natural Fe gradient from the open Weddell Sea to the Antarctic Peninsula. Moreover, shipboard bio-assays will be used to manipulate the conditions under which the microbial community grows and the natural iron gradient in the Weddell Sea will be contrasted with a transect from the Lazarev Sea to the Antarctic continent were we previously did not observe an Fe gradient.

Our proposed study addresses four key questions:

(i) What is the relative contribution of the different sources of iron and the bio-essential metals along a transect from the the Weddell Sea and Lazarev Sea to the Antarctic Peninsula and Antarctic continent?

(ii) Is viral lysis affected by the natural iron concentrations along gradients of iron and does viral lysis affect the ligand production and nature of organic ligands?

(iii) What is the effect of increasing temperature on metal quotas for phytoplankton, viral lysis and ligand production?

(iv) How do expression patters of iron-requiring proteins and iron acquisition proteins change across the transect/ across trace metal gradients?

Work at sea

Physicochemical characterization of the water column will be performed using a trace metal-free titanium CTD-frame, taking samples for major nutrients and trace metals over the water column. Nutrients will be analysed shipboard. Ligands, isotopes and biological variables are sampled from selected depths, whereby from at least one depth (deep chlorophyll maximum or mid mixed layer), all variables will be sampled. Transport of Fe requires stabilisation with organic ligands, thus the concentrations and nature of the ligands as well as the potential sources and interaction with the microbial and viral community will be assessed along these transects as well. This will be done shipboard using Competing Ligand Exchange adsorptive Cathodic Stripping Voltammetry (CLE-aCSV) and additionally samples will be taken to be analysed back home using a combination of Liquid Chromotography (LC) and MS/MS detection for molecular characterisation of the Fe-binding ligands. Samples for dissolved (0.2 µm filtered), labile (unfiltered and acidified) and particulate (0.4 µm filter) metals will be taken and dissolved Fe will be determined shipboard. The remaining samples will be analysed in the home laboratory for all bio-active metals. Additional tracer information will come from stable and radiogenic isotopes including oxygen isotope ratio $\delta^{18}O$ and $\delta^{56}Fe$ measured in the home laboratory.

Abundance of microbes (phytoplankton, bacteria and viruses) will be determined on fresh or fixed samples using flow cytometry shipboard. Phytoplankton community composition will also be determined based on pigment analysis and light microscopy afterwards. Viral lysis of phytoplankton and grazing by micro-zooplankton will be determined simultaneously using a modified dilution approach in combination with flow cytometric analysis. Incubation (24h) will be in an on-deck flow-through incubator with *in-situ* PAR-light level. Viral lysis rates of the prokaryotic community will be estimated using a viral production method. In combination with mitomycin C, the lysogenic infection rate of bacteria will also be determined. Grazing rates will be obtained by using fluorescently labelled bacterial prey. Samples for metagenomic analysis of the viral, and of the pro- and eukaryotic microbial community will be taken from the same depth as viral lysis rates are determined.

Samples will be collected for selected reaction monitoring (SRM) mass spectrometry to measure the concentration of specific Fe acquisition and Fe-requiring proteins in diatoms and bacteria across Fe-gradients. For these measurements, 20L of seawater will be collected from the trace metal sampling system. Additional samples will be collect via high volume *in-situ* pumping from the *Polarstern* underway system.

Onboard bioassay experiments will be done to determine the interactive influence of Fe availability and temperature changes on microbial Fe cycling, ligand production, and nutrient utilization. The bio-assays will be done in deck incubators and consist of up to four treatments: a control, a temperature increase of 2°C, a 2 nM Fe addition and a combination of the temperature increase and Fe addition to assess the effects of temperature and Fe concentrations on the microbial community. At minimum, triplicate 20 L cubitainers for of each treatment will be prepared and sampled for key parameters, described below. These cubitainers, can be subsampled without introducing additional metals.

Bacterial, phytoplankton and viral abundance will be assayed daily via flow cytometry in combination with measurements of photosynthetic efficiency (F_v/F_m). We aim for six day incubations, but will decide the actual length of the incubations based on the daily measurements. Samples for phytoplankton community composition via pigment analysis as well as bacterial and eukaryotic community composition via 16S and 18S rRNA amplicon sequencing will be collected at the beginning and end of the incubation experiments together with samples for measurements of chlorophyll and particulate organic carbon and nitrogen concentrations. The concentrations of dissolved bio-active trace metals will be sampled at the start and end of the experiments for all treatments together with samples for ligand saturations and characterisation. The biomass produced in the bio-assays will also be sampled to assess the metal stoichiometry. Remaining volume will be collected for protein extraction and SRM analyses of a key subset of proteins that will characterise bacterial Fe acquisition strategies and phytoplankton Fe allocation to specific metabolisms.

Preliminary (expected) results

Expected results for the shipboard work include concentrations of Fe and nutrients, flow cytometry data and photosynthetic efficiency (transect and bioassays). Additional results will follow from analysis in the home laboratories (NIOZ and Dalhousie University) as described above and include bio-active metal concentrations, $\delta^{18}O$ and $\delta^{56}Fe$, ligand characterisation, phytoplankton community composition, bacterial and eukaryotic community composition, proteomics, particulate organic carbon / nitrogen, particulate metals, viral lysis rates and grazing rates.

Data management

All raw data will be stored on the NIOZ-server for secured back-up and is available to collaborators upon completion of analysis. After suitable quality control, the metal data will be submitted in the final project year to the GEOTRACES International Data Management Centre (www.bodc.ac.uk/geotraces/) and the National Polar Data Centre (http://www.npdc.nl/) which is linked to other international databases. Two years after submission, data will become publicly available (www.bodc.ac.uk/geotraces/data/policy) and will also be incorporated in the next Data Product. Genetic data will be submitted after publication to the NPDC and Genbank (https://www.ncbi.nlm.nih.gov/genbank/) where it will be publicly available.

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4. PICCOLO AND SOCCOM FLOATS

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Grant No AWI_PS117_04

Outline

The Southern Ocean (>44°S) plays a key role in the global carbon cycle (Brown et al., 2015) and takes up a third of the anthropogenic carbon in the oceans (Mikaloff Fletcher et al., 2006; Khatiwala et al., 2009). A recent study suggests strong decadal variation in the Southern Ocean carbon sink (Landschützer et al., 2015).

The Weddell Gyre, situated in the Atlantic sector of the Southern Ocean, is a strong contemporary sink for atmospheric CO_2 (carbon dioxide) in summer and a source in winter (Brown et al., 2015). This is in contrast with preindustrial times when the region may have been a net CO_2 source to the atmosphere (Hoppema, 2004a). The Weddell Gyre is a key region for the formation of deep and bottom waters (Orsi et al., 1999), but also for the transfer of CO_2 from the upper layers into the abyssal world oceans (Hoppema, 2004b). In addition, in the gyre there is uptake of anthropogenic CO_2 from the atmosphere, which is sequestered locally in the deep water masses (Van Heuven et al., 2011).

In the central and eastern Weddell Gyre, relatively warm waters (Warm Deep Water, WDW), rich in carbon and nutrients upwell, travel onto the Antarctic continental shelf where they become denser, and sink to form Antarctic Bottom Water. Both physical processes (through interaction with atmosphere and ice) and biogeochemical processes (through interaction with the biota and their environment) transform the water mass carbon as the water travels through the gyre. Seasonal sea ice formation and melting has been proposed as a major driver of atmospheric CO_2 drawdown in regions such as the Weddell Sea (Bakker et al., 2008). The properties of dense water spilling off the continental shelf are thought to be set in coastal polynyas (Gordon et al., 2010), where open water allows solar radiation in summer to stimulate phytoplankton activity and blooms.

Key unknowns in the processes affecting these water mass carbon transformations include the physical controls on air/sea/ice gas transfer and how seawater CO_2 is regulated by biological processes, photochemical reactions and changing salinity. Few observations have been made of the wintertime processes.

PICCOLO (Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning) is a multi-disciplinary UK project that will use cutting-edge autonomous technologies and over-winter observations to elucidate the processes influencing carbon uptake in the Weddell Gyre. Multi-season observations in the deep Weddell Gyre, on the continental shelf and under sea ice will quantify rates of carbon uptake, transformation and export as water interacts with the atmosphere, cryosphere and biosphere and then sinks off the shelf into the abyss. PICCOLO will provide a comprehensive understanding of lower limb carbon processes.

SOCCOM (Southern Ocean Carbon and Climate Observations and Modelling) is an NSF-sponsored program focused on unlocking the mysteries of the Southern Ocean and determining its influence on climate (http://soccom.princeton.edu/). A robotic float observing system is complemented by shipboard measurements, instrument and sensor development, and data analysis, including state estimation in conjunction with the modeling program, with an overall goal of improving coupled climate modeling through improvement of representation of carbon and heat exchange in the Southern Ocean. The SOCCOM biogeochemical float program, equipped with oxygen, nitrate, pH and optical sensors, and using empirical algorithms based on shipboard data to calculate the full carbon budget (Williams et al., 2016, 2017) provides year-round profiles of these parameters throughout the Southern Ocean, from which carbon, air-sea carbon exchange, oxygen cycles, and net community production are being estimated (Johnson et al., 2017b). Among other results, SOCCOM floats are showing the strength of CO_2 outgassing from the ocean to the atmosphere within the Antarctic Circumpolar Current (Gray et al., submitted). SOCCOM state estimation and modeling are revealing the three-dimensionality of the upwelling circulation in the Southern Ocean and the seasonal and regional variation of the ocean carbon (Tamsitt et al., 2017; Rosso et al., 2017).

Objectives

- The aim of the PICCOLO float deployments in the central Weddell Sea is to quantify seasonal physical and biogeochemical processes affecting the carbon cycle in Warm Deep Water as it upwells in the Weddell Gyre and is modified in its circuitous route towards the dense water formation regions we will study with the PICCOLO cruise, scheduled for 2020/21. This contributes to the PICCOLO overall objective to define, quantify and provide a mechanistic understanding of the key processes controlling the rate of Southern Ocean carbon uptake.
- The SOCCOM Observational Theme is developing and implementing a new observing system for carbon, nutrients, and oxygen that complements and expands on the existing observing system for heat and freshwater. The SOCCOM float deployments on PS117 will be part of the large array (~200) of profiling floats with biogeochemical sensors throughout the Southern Ocean.
- A third aim is to extend the unique AWI-led record of deep ocean carbonate chemistry along the Greenwich Meridian and the Kapp Norvegia to Joinville Island section (Bakker et al., 2008; Van Heuven et al., 2011; Hoppema et al., 2015; Olsen et al., 2016). The repeat section will be extended by taking samples for dissolved inorganic carbon (DIC), total alkalinity (TA), dissolved oxygen and nutrients (if not taken by other expedition participants) at many CTD stations. The repeat sections have been sampled for carbonate and relevant additional parameters by AWI since 1992 (ANT-X/4), while also previous data from the 1970s and 1980s exist, thus constituting one of the longest time series of repeat sections in the Southern Ocean.
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The activities on PS117 are a collaboration between the UK PICCOLO Research Program (2017-2022, NE/P021395/1), the US SOCCOM Program (NSF Award PLR-1425989), AWI scientists, the UK MetOffice (UKMO) and the ENVEast Doctoral training partnership (NE/L002582/1).

Work at sea

We aim to deploy 4 Core-Argo floats and 10 Biogeochemical Argo (BGC) floats (Table 4.1). Table 4.1 lists the providers of these floats and the sensors on the floats. Floats will be deployed at selected CTD stations across the Antarctic Circumpolar Current and the Weddell Gyre, on the Greenwich meridian section and the Fahrbach section from Kapp Norvegia to Joinville Island. Deployment locations will depend on the status at the time of SOCCOM floats

in the region (http://soccom.princeton.edu/content/soccom-map-room), sea ice cover, and will be determined using particle tracking in numerical models. Ideally, floats are deployed over at least 1,000 m of water depth. SOCCOM floats must be deployed in at least 2,500 m of water depth. Floats should be deployed in ice-free conditions to enable satellite communication in the week following deployment.

In-situ calibration is crucial for deployments of BGC Argo floats. Therefore calibration samples for DIC, TA, pH, salinity, dissolved oxygen, nutrients, pigments (HPLC – High performance liquid chromatography) and POC (particulate organic carbon) will be taken from the CTD rosette at the deployment stations of all BGC Argo floats. Core Argo floats do not need calibration samples.

In addition, samples will be taken for DIC, TA, dissolved oxygen and nutrients, if not done by other participants, at most CTD stations during the cruise. Oxygen analyses will be carried out on board.

Tab. 4.1: Summary of platforms and associated sensors to be deployed on PS117

	Num-ber	Tempe rature/ Salinity	Chl. fluores cence	Oxy-gen	pH	Nitrate	Optics
UKMO Core Argo float	4	✓	-	-	-	-	-
SOCCOM BGC Argo float	7	✓	✓	✓	✓	✓	✓
UKMO BGC Argo float	3	✓	✓	✓	-	-	-

Expected results

Expedition PS117 will enable PICCOLO to follow the processes affecting the carbon transported within a water mass as it upwells in the Weddell Gyre through to sinking to the deep ocean. The float releases will contribute to the overall SOCCOM aim of unlocking the mysteries of the Southern Ocean and determining its influence on climate. The expedition will extend the 0°W repeat section to 2018/19.

Data management

- For the float data we will adopt the Argo data management and data access rules (http://biogeochemical-argo.org/data-management.php, http://biogeochemical-argo.org/data-access.php). Therefore, regardless of the source (SOCCOM or PICCOLO floats from the UK MetOffice) all Argo and BGC Argo float data will be similarly formatted and distributed from the two (redundant) GDAC ftp sites: ftp://usgodae.org/pub/outgoing/argo, ftp://ftp.ifremer.fr/ifremer/argo.
- The physical oceanographic data of AWI will be submitted to Pangaea. The chemistry data from CTD samples will be added to this and will be submitted for inclusion in the GLODAP (www.glodap.info) data synthesis product (Olsen et al., 2016). The UK-funded data will also be made publicly available via the British Oceanographic Data Centre (https://www.bodc.ac.uk/). Shipboard data supporting SOCCOM float deployments will also be made available through the CCHDO (http://cchdo.ucsd.edu) and NCEI (National Centres for Environmental Information).

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5. OCCURRENCE OF MICROPLASTICS IN THE ANTARCTIC SEAS

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Grant No AWI_PS117_05

Objectives

We aim to advance our knowledge and understanding of the sources of microplastics (MP) in the remote Antarctic marine ecosystem. By applying material flow analysis and integrating the results into an ocean circulation model, we will evaluate the evidence that MP can cross the Antarctic Circumpolar Current (ACC) into the Southern Ocean around Antarctica.

A successful outcome will include achieving the following goals:

- Providing baseline information on concentrations, composition and distribution of MP in surface waters from the Southern Ocean,
- Evaluate the sources of MP in the Southern Ocean, by: (1) comparing MPs in the more anthropogenically impacted Scotia Sea (SS) and Western Antarctic Peninsula (WAP) versus relatively pristine Weddell Sea (WS) and (2) modeling MP transport within and to/from Antarctica. These comparisons will be based on: (a) characterization of MP properties, such as particle morphology, polymer composition, extent of degradation, and (b) analysis of persistent organic pollutants (POPs) loads, and (c) examination of the microbial communities of the MP (Plastisphere).
- Modeling the potential contribution of local sources, such as Waste Water Treatment Plant (WWTP) effluents from vessels and research bases, for MP contamination of the Southern Ocean around Antarctica.

Work at sea

Water will be sampled for MP with a Manta Trawl and/or by filtering the water column via pumping seawater from beneath the vessels (approx. 12 m depth). The MP collected will be analyzed for particle morphology, POP and Plastisphere microbial community characterizations.

In addition, water for comparative microbial profiling (surrounding sea water vs. MP) will be sampled with a bucket or niskin bottle or CTD. If particles conspicuously appear to be plastic as determined by eye (e.g. based on color or shape), these will be analyzed for microbial community composition first and subsequently identified using FTIR.

A surface-trawling plankton net (Manta Trawl) will be used to collect MP in surface water samples and towed at the surface. The manta trawl (aperture: 60 cm × 18 cm) will be equipped with a 333 µm mesh net and a removable cod end, as well as a mechanical flowmeter. The

manta trawl (≈ 15 kg) will be deployed by an on-board automatic crane, as well as a steel rope and karabiner long enough to allow for a flat sampling angle (≤ 30°) at the side of the ship, outside the wake. Four to 20 tows of 5 km each with a tow speed of min. 0.5 m/s (technical lower limit mechanical flowmeter) to max. 4 m/s will result in approximately 540 m^3 of filtered seawater per sample and a potential total of 10,800 m^3. A flowmeter will be employed at the center of the Manta opening to quantify the sampled surface area and volume (volume Manta 0.108 m^3). After every tow the Manta will be hauled from the water and the content of the removable cod end will be rinsed into Bogorov counting chambers using 0.22-µm filtered seawater. Conspicuous particles will be sorted and characterized microscopically.

MP from pumped water: To address the MP load of water samples, we sample surface waters by using on-board pumps (seawater pumps of RV *Polarstern*). The water will be filtered onto 10 µm stainless steel meshes. The meshes will be stored frozen for later polymer analysis in the laboratory. MP collected in this way may be challenging to extract DNA from, so a subset of samples will be preserved instead for CLASI-FISH community visualization. Samples for microscopy via FISH and CLASI-FISH will be fixed in paraformaldehyde (for less than 24 hours) then transferred to 50 % ethanol in PBS for storage at -20°C.

To compare free-living microbial communities with those on MP, we will filter 2-4 L by drawing water from below or at the surface via bucket or Niskin bottle, through a 0.2 µm Sterivex™ cartridge filter (Millipore) to collect microorganisms suspended in the ambient surface water and then flood the filters with 2.0 ml of PureGene lysis buffer.

Preliminary (expected) results

We expect to perform 10 to (maximal twenty) tows with the Manta trawl, which would result in an average of approximately 300 m^3 of filtered seawater per successful sample and a total of 3,000 – 6,000 m^3. We also attempt to prepare the samples (rinsing, cleaning, removing of organic material (such as plankton and debris) by enzymatic digestion) and transfer them into a Bogorov counting chamber for visual inspection using a stereomicroscope (Olympus SZ61) equipped with a camera (Olympus SC50) and connected to the imaging software CellSens Entry. Putative anthropogenic particles will be sorted, characterized microscopically and photographs will be taken for ease of retrieval in the home laboratory. Particles which might appeared to be plastic as determined by eye (e.g. based on color, texture and shape), will be analysed for microbial community composition first and subsequently identified using FT–IR. Samples for microbial DNA-analysis will be fixed in 2 mL PureGene lysis buffer, samples for microscopy via FISH and CLASI-FISH will be fixed in paraformaldehyde and will then be transferred to 50% ethanol in PBS for storage at –20°C.

Samples will have been taken from pumped seawater intake in the on-board wet lab. The water will have been filtered through a stack of geological sieves (a 20 µm sieve (combined with 100 µm and 300 µm sieves). Samples will have been sealed with metal lids, labelled by the lowest applied mesh size and stored in v:v 50:50 suspended sample:EtoH at 4° C.Quality control and contamination protection is a crucial aspect and we will tackle this issue very seriously, applying all precautionary measures as described by Mani et al. 2018.

We expect to find microplastics in the samples, however, the kind of plastic particles, as well as polymers, further characteristics and their origin are unknown and no data from former cruises in this geographic area are available yet.

Data management

Microplastic samples will either be destroyed by analysis or those not analysed will be stored at the home laboratory at University of Basel. All sequence data will be deposited in EBI's European Nucleotide Archive and will conform to the minimum information standards recommended by the Genomics Standards Consortium (http://gensc.org/projects/mixs-gscproject/). Metadata and results will be stored at data servers of the University of Basel.

After a thorough quality control, processing and publication in a peer reviewed journal, the processed data will be stored in the PANGAEA data base.

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6. SEA ICE PRODUCTION AND ECOLOGY STUDY (SIPES 2)

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Grant No AWI_PS117_06

Objectives

SIPES 2 is designed as an inter-disciplinary field study focussing on the inter-connection of sea ice properties, sea ice biology, biological oceanography and top predator ecology. Pelagic food webs in the Antarctic sea ice zone can depend significantly on carbon produced by ice-associated microalgae. Future changes in Antarctic sea ice habitats will affect sea ice primary production and habitat structure, with unknown consequences for Antarctic ecosystems. Antarctic krill *Euphausia superba* and other species feeding at the ice-water interface layer play a key role in transferring carbon from sea ice into the pelagic food web, up to the trophic levels of birds and mammals (Flores et al. 2012, David et al. 2016, Kohlbach et al. 2017, 2018). To better understand potential impacts of changing sea ice habitats for Antarctic ecosystems, AWI's section of Polar Biological Oceanography in cooperation with Wageningen Marine Research (WMR), the Royal Belgian Institute for Natural Sciences (RBINS) and the Australian Antarctic Division (AAD) join forces to investigate the importance of sea ice in the support of living resources and ecosystem functioning. This will be achieved by 1) quantitative sampling of the under-ice and pelagic metazoan communities and environmental parameters; 2) using molecular and isotopic biomarkers to trace sea ice-derived carbon in pelagic food webs; 3) measuring sea ice properties as well as ice algal and under-ice herbivore distribution with an instrumented remotely operated vehicle (ROV).

In the Southern Ocean, the exploitation of marine living resources and the conservation of ecosystem health are tightly linked to each other in the management framework of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). Antarctic krill is important in this context, both as a major fisheries resource, and as a key carbon source for Antarctic fishes, birds, and mammals. Similar to Antarctic krill, several abundant endothermic top predators have been shown to concentrate in pack-ice habitats in spite of low water column productivity (van Franeker et al. 1997). Investigations on the association of krill and other key species with under-ice habitats will be complemented by systematic top predator censuses in order to develop robust statements on the impact of changing sea ice habitats on polar marine resources and conservation objectives.

Work at sea

SUIT sampling

A Surface and Under-Ice Trawl (SUIT: van Franeker et al. 2009) will be used to sample the pelagic fauna down to 2 m under the ice and in open surface waters. During SUIT tows, data from the physical environment will be recorded, e.g. water temperature, salinity, ice thickness, and multi-spectral light transmission. Core SUIT deployments will be conducted along transects from open water into the closed pack-ice and back in a restricted survey area which will be defined based on sea ice conditions and biological indicators. Intermediate SUIT hauls will be conducted during the passage between moorings. At the planned ice stations, SUIT hauls will be conducted on arrival and/or departure to obtain the maximum possible comparability of under-ice species composition and abundance and under-ice sensor data with data collected during the ice stations.

Pelagic sampling

We aim to also investigate deeper-dwelling key species of the pelagic food web, such as euphausiids, amphipods, and myctophids. A Multiple opening Rectangular Midwater Trawl (M-RMT) will be used at many SUIT locations. For biomarker analysis, Particulate Organic Matter (POM) will be collected from filtered seawater obtained from the CTD rosette. Chlorophyll samples will be filtered from melted ice cores and CTD rosette water samples to calibrate fluorometers built in the ship's CTD and the SUIT. In addition, *Polarstern's* EK60 echosounder will be running during steaming to map the distribution of resources in the water column continuously and identify potential hot spots for target hauls for SUIT and M-RMT.

ROV sampling

ROV sampling well be conducted concomitantly with SUIT sampling and ice stations. The ROV will be deployed from the ship and will measure under-ice irradiance and radiance spectra using ROV-mounted up-ward looking hyperspectral radiometers (Meiners et al. 2017). The ROV will also be equipped with video and a stills camera to take images of the herbivore distribution at the ice-water interface layer.

Sea ice work

On-ice work will consist of ice coring and bio-optical measurements. Ice coring and bio-optical measurements will be done at multiple sites in order to capture the small-scale variability of ice algal biomass and physical properties. At each coring site, cores will be collected for pigments; biomarker analysis; salinity; temperature, ice texture, sea-ice meiofauna and POC. The bio-optical measurements are an important prerequisite for the calibration of hyper-spectral light profiles obtained from SUIT and the ROV. They require the deployment of an L-arm under the ice with a mounted spectral radiometer to acquire the spectral light properties of the sea ice and the under-ice environment. At L-arm survey sites, ice cores will be extracted and processed for pigment content in order to determine the relationship of ice algal biomass with the under-ice spectral light properties.

Biomarker analysis

For later biomarker and diet analysis, samples of phytoplankton, zooplankton, sea ice POM and water column POM collected with the CTD rosette, SUIT, other nets and ice corers will be stored in ethanol or frozen at -80°C on board.

Top predator censuses

During steaming, surveys of top predator densities will be conducted mainly from observation posts installed on the flying bridge. Standard band transect methods are used, with snapshot methodology for birds in flight, and line-transect methods for marine mammals. To improve

spatial coverage, top predator surveys will be conducted from a helicopter following rigid grid patterns.

Expected results

We expect to obtain a comprehensive dataset of the distribution and diversity of pelagic and under-ice fauna along the Weddell Sea cross-section. In conjunction with hyperspectral and other environmental data from the ROV, our environmental datasets will help to model the relationship of ice-associated biota with their habitat. Biomarker and diet samples will be analysed in the home laboratories and will contribute to a more quantitative understanding of the role of ice algal production and sea ice associated zooplankton in the Antarctic food web. In combination with top predator census data, interdependencies of the sea ice ecosystem may be mapped from the level of physical parameters to the distribution of large mammals.

Data policy

Almost all sample processing will be carried out in the home laboratories at AWI and WMR. This may take up to three years depending on the parameter as well as analytical methods (chemical measurements and species identifications and quantifications). As soon as the data are available they will be accessible to other expedition participants and research partners on request. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA and the Australian Antarctic Data Centre, and will be open for external use.

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7. ALGENOM-2: MOLECULAR ECOLOGY AND EVOLUTION OF PRIMARY PRODUCERS

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Grant No AWI_PS117_07

Objectives

Microscopic 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 two different research projects addressing the diversity and ecology of these microscopic organisms in the pelagic of the Southern Ocean. Sampling at PS117 is the continuation of our activities performed two years ago on PS103. 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). 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. Work based on similar sampling of the taxon revealed the presence of three distinct, previously unrecognized species; our sampling at PS117 will focus on improving our sampling of especially that newly revealed species which has the broadest biogeographic range.
- Get insights into community-wide gene expression patterns, as well as transcript sequence variation at the intra- and interspecific level, accompanying environmental gradients across the ACC in communities of microscopic eukaryotes for the "Sea of Change" project[1] .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. A set of samples collected in a similar manner during PS103 has in the meanwhile been sequenced and is currently subject to bioinformatics analyses. The repeated sampling along a similar transect will provide a possibility to assess the stability of latitudinal changes in transcript repertoire and community composition.

[1] http://genome.jgi.doe.gov/SeaofArctiOcean/SeaofArctiOcean.info.html

Work at sea

Sampling will be performed at 20-40 stations by CTD casts with water collection at the depth of chlorophyll maximum and near the surface, and with hand-held phytoplankton nets. Samples will be subdivided and processed by a combination of methods. Seawater subsamples will be filtered onto 1.2 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 large scale shotgun sequencing for characterizing microbial community composition and gene expression 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 analysis of microphytoplankton and for electron microscopic identification. To characterize patterns of intraspecific genomic variation in our target species *Fragilariopsis kerguelensis*, 20-30 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.

Preliminary (expected) results

Similarly to what is more prominently perceived in the northern hemisphere, Southern Ocean plankton will also undergo substantial biogeographic shifts due to ocean warming and shifting oceanographic regimes in the coming decades (Pinkernell and Beszteri, 2014). Similar, although not identical, biogeographic shifts seem to have accompanied past climatic changes like deglaciations (Kloster et al., 2018). Alongside such ecological processes, however, evolutionary processes including adaptation to novel combinations of environmental conditions also seem to have acted upon *F. kerguelensis* or similar open ocean planktonic taxa. The results from our sampling at PS117 are expected to contribute to a better understanding of the magnitude of such evolutionary processes at the intraspecific level and/or those that have accompanied speciation, which, in the pelagic Southern Ocean habitat, seems to often have been driven by ecological specialization to different latitudinal regimes, rather than geographic isolation. Complementing our results from PS103, the newly collected strains and nucleic acid samples will mainly be used to test the robustness of our initial observations on morphological, eco-physiological and population genomic differentiation (Postel, Glemser, Salazar, Beszteri et al, unpublished) and to refine them at the intraspecific level.

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 expedition is nucleotide sequence data which will be deposited in the corresponding databases of the International Nucleotide Sequence Database Cooperation (INSDC: http://www.insdc.org/).

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8. COMBINED EFFECTS OF TEMPERATURE AND ORGANIC MATTER AVAILABILITY ON DEGRADATION ACTIVITY BY ANTARCTIC BACTERIOPLANKTON

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Grant No AWI_PS117_08

Objectives

Global warming poses new threats to marine ecosystems since rising seawater temperature potentially induces cascading effects in biogeochemical cycles and food webs. In Antarctic marine systems, low seawater temperature, and the low availability of labile organic matter are major environmental constraints on bacterial growth and degradation activity. However, temperature and the availability of resources for heterotrophic bacteria undergo considerable change induced by climate warming combined with subsequent ice melt and changes in primary productivity. Changes in temperature and resource availability can induce shifts in the structure and composition of bacterioplankton communities but there is a limited understanding of how changes in community composition affect community metabolism and functioning. Extracellular enzymes produced by heterotrophic bacteria play a pivotal role in the turnover of marine organic matter. These enzymes accomplish the hydrolysis of high-molecular weight organic matter outside the bacterial cells, thereby initiating the degradation of polymeric substances that contain the by far largest share of organic carbon in seawater. Comparing ratios of glucosidase to aminopeptidase, two major extracellular enzymes in seawater, latitudinal trends show that glucosidase predominates in the equatorial zone while the importance of aminopeptidase increases with increasing latitude (Christian and Karl, 1998). It is unknown whether different enzyme classes have consistently different activation energies, so that the composition of substrates and the structural complexity of molecules may impact the temperature sensitivity of extracellular enzymatic reactions and the subsequent turnover of organic substances.

Work at sea

The planned working programme continues studies of previous cruises (PS103, PS111) to increase the spatial resolution of sampling in the central Weddell Gyre. Furthermore, the intended expedition track of PS117 provides the opportunity to add measurements in the western Weddell Sea, in the proximity of the Antarctic Peninsula. At *ca*. 20 stations along the envisaged expedition track 5-6 discrete depths in the upper 100 m of the water column will be sampled for the analysis of organic matter, bacterial abundance, activity and community composition. Field work will be combined with onboard experiments that investigate the temperature dependence of polysaccharide degradation by the natural communities at different temperature settings. More specifically, experiments will investigate the temperature effect on the bacterial turnover of glucose, laminarin and chitin. Glucose represents a very labile substrate for bacterial growth. The monosaccharide does not require any enzymatic reworking prior to transport across the bacterial cell memberane and is, therefore, easily accessible. Laminarin is a polymer of glucose units linked with beta-glycosidic bonds. It is a major storage glucan of bloom-forming phytoplankton and considered to be one of the most abundant types of carbohydrate in the marine environment (Painter 1983). Laminarin is too large for direct bacterial uptake and has to be enzymatically hydrolyzed outside the cell. In a

third treatment natural bacterial communities of the Weddell Sea will be supplied with chitin. Chitin is a structural homologue of cellulose and composed of (1→4)-β-linked N-acetyl-D-glucosamine. Hydrolysis rates of chitin in seawater are low. Hence, it must be considered as a more complex carbon source that requires specific chinolytic enzymes (Beier 2003). Our onboard experiments will explore whether temperature affects the bacterial degradation of these carbohydrates differently.

Expected results

The expected results of this project will increase the knowledge on the response of heterotrophic bacterioplankton to environmental changes in Antarctic marine systems. It will contribute to a better understanding of temperature effects on the composition of bacterial communities and the turnover of organic matter. Data will be used to explore the potential of rising seawater temperature to interact with resources for bacterial growth, thereby potentially enhancing bacterial activity in warming Antarctic marine systems beyond projections derived from thermodynamic equations.

Data management

All data collected and generated by this project will be submitted to the central Pangaea database of SPP 1158. DNA and RNA sequence data will be submitted to public databases (Genbank, NCBI).

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9. MOLECULAR ECOLOGY, PHYSIOLOGY AND LIFE HISTORY TOOLS TO MONITOR THE POPULATION OF *DISSOSTICHUS MAWSONI* OVER TIME AND IN RELATION TO PROTECTION MEASURES IN THE WEDDELL SEA

C. Papetti (UNIPD, not on board), E. Riginella (SZN), N. Koschnick (AWI), M. La Mesa (ISMAR-CNR, not on board), JA Caccavo (UNIPD, not on board), L. Zane (UNIPD, not on board), M. Lucassen (AWI, not on board)

Grant No AWI_PS117_09

Objectives

The Antarctic toothfish *Dissostichus mawsoni* is a mesopredator in the Antarctic marine food web. It feeds mainly on the silverfish *Pleuragramma antarctica* (and thereby is a trophic competitor of penguins for it) and is the prey of larger predators (e.g. seals, killer whales). The

toothfish has a commercial value worth between 20 and 100 dollars per kg and is therefore the target of an economically relevant fishery in the Southern Ocean (Hanchet et al. 2015). Current Antarctic fisheries management by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR, *www.ccamlr.org*) largely depends on mathematical/statistical models to determine stock sizes and catch rates, but these models frequently fail in the absence of adequate and accurate biological and physical data.

After 20 years of the fishery experiencing very high yields, still little is known about the biology of toothfish, and this lack of knowledge impinges on the sound management of the species.

Fishery is not the only factor potentially affecting the abundance and health of toothfish populations. Climate change — water temperature rise, ocean acidification, changes of sea ice coverage and further oceanographic parameters — have the potential to affect the entire Antarctic ecosystem, altering food and light availability and causing physiological stress. Thereby, these factors may act synergistically on population dynamics and structure especially on species already facing fishery pressure.

Although currently only the Western Antarctic is facing dramatic climate change, recent results from IPCC-scenario simulations reveal a pronounced sensitivity of the south-eastern Weddell Sea to projected environmental changes. Hellmer et al. (2012) predict a 0.5-0.7° C increase in the temperature of bottom water masses, which occur in the potential habitat of adult Antarctic toothfish on the continental slope in depths between 550 m - 2,100 m. Inflow of melting water and "warm" bottom water reaching the shelf will cause basal melting of the shelf ice (e.g. the Ronne-Filchner ice shelf), which may induce large-scale shifts in water masses and temperature distribution, including increased PCO_2. Although these shifts in temperature are quite small, they may have significant influence on animal performance of highly cold-adapted, stenothermic species like *D. mawsoni* and thus consequences for species abundance and distribution. The cold-adapted toothfish — exposed already to fishery pressure — may thus require additional management and conservation measures to minimize the effects of environmental changes and human impact (Griffiths et al. 2017).

There are proposed measures to protect, conserve and limit the fishery of this species. The fishery of *D. mawsoni* in the Ross Sea has been partially closed since 1st December 2017 when the (largest in the world) Marine Protected Area (MPA) took effect. A proposal for an MPA in the Weddell Sea has been prepared by Germany and proposed by the EU under the CCAMLR.

To be able to apply sound management to the Antarctic toothfish resources in the Weddell Sea, to monitor MPA effectiveness and species trajectory, we aim to understand:

- **Population connectivity and demography** via life history data, ecological and genetic information. This implies the collection of samples from muscle or fin, photos for morphology description, otoliths for age determination and microchemistry analysis, gonads for sexual maturity and fecundity assessment.
- **Specific adaptations** that may hinder the toothfish survival under warming conditions. This implies the collection of samples of all body tissues deep frozen and tissues fixed in formalin.
- **Health of the population/stock** (the "hologenome" from toothfish). This implies the collection of faeces and different tracts of gastrointestinal apparatus (i.e., midgut and hindgut) and sites within gut locations (i.e., content and wall), buccal swabs. This design will allow us to determine if distinct bacterial taxa are enriched in the different gut locations (i.e., midgut and hindgut), if microbial communities in the gut content (lumen) differ from those associated directly with the gut wall (mucosa), and how the relationship between communities within the content and wall changes along the gut.

This research will also contribute to the testing and the further development of stock hypotheses for Antarctic toothfish (*Dissostichus mawsoni*) for the Atlantic sector of the

Southern Ocean (CCAMLR statistical area 48), which were developed under CCAMLR (CCAMLR, 2018).

Work at sea

To investigate our aims, good fish material in the most pristine condition possible is needed.

Fish will be caught with vertical longlines according to the project by Dr. Hain (AWI, see Chapter 10). Additionally, baited traps applied to a newly developed lander system (M. Lucassen, unpublished, AWI) will be used as possible secondary source of specimens and of further Antarctic fish species. These traps will be deployed opportunistically along the expedition leg in conjunction with the vertical longline deployment.

From each catch, standard ecological and catch parameters (sampling location coordinates, depth, species composition in case of bycatch species, biometric parameters such as biomass, length and weight distribution etc.) will be determined in collaboration with scientists mentioned in Dr. Hain's project (AWI, see Chapter 10). After the catch, live fish will be placed into the aquaria systems, kept alive and controlled regularly. Dead fish will be sorted and sampled directly. A unique individual identifier will be assigned to a sub-sample or to all fish collected, thus allowing to record ancillary information such as sex, length, maturity stage, and age for each fish for further use in follow-up analyses. This information will be recorded in close collaboration with the other toothfish team (see Chapter 10). External appearance of a few single fishes will be digitally recorded.

More specifically, work for each aim implies:

- **Population connectivity and demography.** Sampling entails dissection of a small amount of lateral muscle tissue and/or fin clips, under clean conditions, and storage of tissue samples in 2 ml of 99% absolute ethanol (at 4°C). A replicated sample of these tissues and possibly of additional organs (spleen, blood, brain, liver, heart) of interest will be preserved at -80°C. Otoliths and gonads will be collected in parallel and stored dry or in formalin, respectively.
- **Specific adaptations.** For gene expression profiling and genome sequencing, we will dissect all available tissues together with blood and serum from undamaged fish directly after short recovery from the haul. Depending on available specimens, short-term exposures to elevated temperatures or specific diets will be conducted. At the end, these fish will be sacrificed and sampled. Tissue samples will be excised, flash-frozen in liquid nitrogen and stored at -80°C or fixed in formalin until in Bremerhaven (Germany). These samples will also serve for the long-term molecular genetics and physiological sample archive of the AWI working group of Dr. Lucassen, for which sampling started in 2003 for the eastern Weddell Sea and the Antarctic Peninsula. This will allow in the long-term for the detection of spatio-temporal biodiversity and population shifts and comparison among Antarctic regions.
- **Health of the population/stock.** All fish sampled for aim 1 and 2 will be dissected to separate the entire gut contents, which will be stored at -80°C until further processing. No fish with punctured intestinal tracts will be considered. From each fish, the intestinal tract will be further dissected using a sterile scalpel to separate the midgut (immediately after the stomach) and the hindgut (immediately before the anus) sections. For each of these two sections, the gut content will be squeezed out and the gut wall separated. Gut wall samples will be washed twice with sterile artificial seawater to remove any remaining gut content. All samples for aim 3 will be frozen at – 80°C.

Expected results

We expect that our results will improve the understanding of the biology, ecology and adaptations of Antarctic toothfish, the ability to target management efforts to biologically

relevant population units and the opportunity to set the stage for future monitoring of the effectiveness of management and conservation measures of toothfish. Results must be transferred to the international bodies focused on the living Antarctic resources and involved in collecting scientific knowledge (fishery-independent) necessary for the rational use and protection of Antarctic biodiversity — e.g. Scientific Committee on Antarctic Research (SCAR) and the CCAMLR.

Data management

Standard fisheries data from the vertical longline hauls will be reported by scientists leading our sister project (Dr. Hain et al., see chapter 10) to CCAMLR.

All other data will be published in internationally recognised, peer-reviewed scientific journals and *Polarstern* and the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research will be properly acknowledged. The molecular data will be submitted to the respective database (NCBI, EMBL), all other data will be stored in Pangaea. Samples may become available for other scientists on request.

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10. PILOTING VERTICAL LONGLINES IN SUPPORT OF THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF ANTARCTIC TOOTHFISH (*DISSOSTICHUS MAWSONI*) IN THE WEDDELL SEA UNDER CCAMLR[2]

S Hain (AWI, not on board), V. Laptikhovsky (CEFAS), R. Gornia (AWI)

Grant-No. AWI_PS117_10

Objectives

The Antarctic toothfish (*Dissostichus mawsoni,* Fig. 10.1) is a large (up to 2 m in length and 80 kg in weight), long-lived (up to 50 years), demersal living top predator (Fig. 1). The species is increasingly targeted and harvested by commercially operated fishing vessels in various parts of the Southern Ocean, including the north-eastern Weddell Sea (CCAMLR statistical area 48.6). A better understanding of the life cycle, spawning sites and life history parameters of *D. mawsoni* is crucial for the sustainable management of this commercial fishing activity in order to conserve its stock and its role in the wider ecosystem and food chains. Juvenile and sub-adult *D. mawsoni* are often found on the continental shelf, whereas the habitat of adult

[2] Commission for the Conservation of Antarctic Marine Living Resources

specimens is the continental slope in water depths between 550 m and 2,100 m. Collection of Antarctic toothfish, especially live individuals, is logistically challenging because of the environment they inhabit (Hanchet et al. 2015). Sampling must occur in deep water, in and near mobile sea ice, use standardised and comparable samplings gear, and bring large fish to the surface and allow live transport into holding tanks within the vessel. Antarctic toothfish is hardly caught by trawls. The hundreds of Agassiz and bottom trawl samples taken by AWI in the Weddell Sea over the last 35 years yielded less than 40 specimens. The standard way of catching Antarctic toothfish applied by the commercially operated fishing vessels makes use of horizontal longlines, often several kilometers long with thousands of baited hooks. However, it is very difficult (if not impossible) to deploy such longlines from a normal scientific research vessel such as *Polarstern*. Therefore, the project will pilot a novel, targeted approach by catching a limited amount (max. 5 tonnes) of toothfish with vertical longlines. Vertical longlines have been used occasionally to catch Antarctic toothfish in experimental settings (Kokorin & Serbin, 2009), through sea ice (Parker et al., 2013, Parker et al., 2016) and for special research surveys (Parker et al., 2015). Piloting the use of vertical longlines from *Polarstern* combines the long-term experience gained by AWI in deploying oceanographic moorings in the Weddell Sea with the fisheries expert guidance kindly provided by CCAMLR partners from UK and New Zealand.

The main objectives of the research are:

- to demonstrate that important and targeted investigations on D. mawsoni (e.g. tagging, sampling of toothfish tissues, especially for genetics and genomics) can successfully be carried out via vertical longlines deployed by research vessels such as *Polarstern* ;
- to gain data and information in cooperation with the research led by Dr. C. Papetti and M. Lucassen (see chapter 9) for a better understanding of the population structure and dynamics of D. mawsoni as a key species in the Weddell Sea ecosystem and to improve knowledge about its life cycle and its role in the wider ecosystem and food chains;
- to provide data for testing and further developing the D. mawsoni population hypotheses for CCAMLR statistical area 48, which were established at the CCAMLR expert workshop held in Berlin in February 2018.

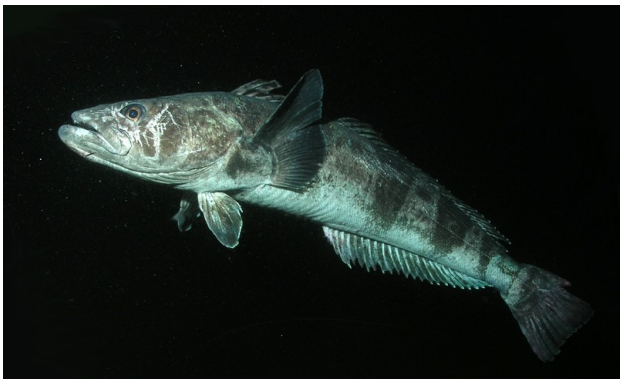

Fig. 10.1: Dissostichus mawsoni, the Antarctic toothfish, is the largest of the notothenioid fish to inhabit the Southern Ocean. Image © Rob Robbins

Work at sea

The biological sampling of Antarctic toothfish will be undertaken with 9 vertical longlines / moorings (see Fig. 10.2) to be deployed in 3 clusters at 800 m, 1,000 m and 1,200 m water depths at different geographical locations along the route of PS117. Preferred sampling areas

would be the eastern Weddell Sea (e.g. around Maud Rise or near the German Neumayer III station) and, if possible, on the continental slope around the tip of the Antarctic Peninsula. The exact locations will depend on sea ice cover and time available. The vertical longlines will be deployed via the mid-ship sliding beam when *Polarstern* is stationary. This means that the line will enter the water vertically in approx. 1 m distance from the ships side. During deployment and recovery of the gear only few baited hooks will be exposed at a time, thereby avoiding any incidental bird catch / mortality. Due to the expected heavy sea ice conditions, the vertical longlines will end around 100 m below the sea surface to avoid being dragged by ice flows. Soaking time will be between 10 and 20 hours. An uw-water camera with a focal depth of 2-5 meters will be installed in each longline. Still photos of 2-3 hooks will be taken each 2-5 minutes to observe the behaviour of toothfish and other potential by-catch species, as well as potential depredation by scavenging amphipod species. The deployment and hydroacoustic release of the vertical longlines will be monitored by the acoustic positioning system Posidonia. Following the release of the vertical longline, the main bottom weight (single railway carriage wheel) will remain on the sea floor.

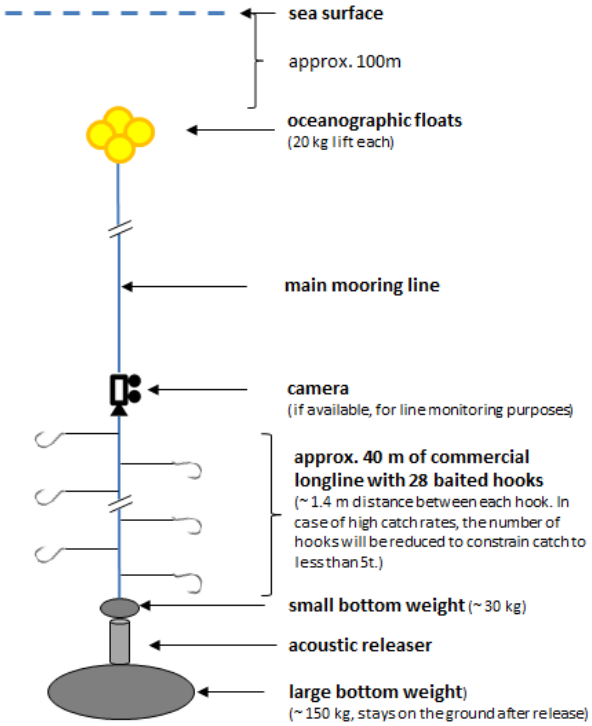

Fig. 10.2: Schematic view of the vertical longline / mooring design to be deployed during Polarstern expedition PS117

Any toothfish caught will be handled and studied by an international team of scientists. The scientists on board will collect biological data in line with the Scheme of International Scientific Observation (SISO) of CCAMLR[3], which includes length, weight, sex, maturity stage, and gonad weight of a subset of caught toothfish and potential by-catch. Standard biometric fisheries and body mass index measurements (length, girth, weight etc.) will be taken from all *D. mawsoni* specimens. On all terminally sampled toothfish specimens biological investigations for a suite of genetic, reproductive, dietary, genomics and stable isotope

[3] Further information about CCAMLR SISO is available at https://www.ccamlr.org/en/science/ccamlr-scheme-international-scientific-observation-siso

turnover analyses will be performed by the experts under this project and the researchers from the University of Padua and AWI (see chapter 9). All toothfish specimens not needed for this research will be tagged with standard CCAMLR t-bar tags in accordance with the CCAMLR tagging procedures / guidelines[4] and released after collection of weight and length data in order to understand the longer-term links with other potential parts of this population. Biological samples of specimens from other (by-catch) species caught on the sampling gear will be retained to understand species composition and life histories of those species in the areas sampled.

Preliminary (expected) results

During this pilot project, both the research teams involved and the crew of *Polarstern* will gain valuable experience in using vertical longlines to catch Antarctic toothfish and in handling this species for scientific research studies. This experience will be used to modify the catch and research methods, as appropriate, for a more standard use in future, e.g. in the context of the research and monitoring to be carried out once the Weddell Sea MPA (currently proposed by the EU on the basis of work carried out by Germany / AWI) has been adopted by CCAMLR. At present, it is difficult to predict how many *D. mawsoni* specimens will be caught - 5-10 specimens per longline would be a success.

Data management

All biological and biometric data obtained under the CCAMLR SISO will be reported to CCAMLR together with data on the number of fish tagged and released and any observations from analyzing the uw-camera photos.

Other data will be published individually or in collaboration with the researchers of the second PS117 toothfish project (see chapter 9) in internationally recognized, peer-reviewed scientific journals. *Polarstern* and the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research will be properly acknowledged. The molecular / genomic data will be submitted to the respective database (NCBI, EMBL), all other data will be stored in Pangaea. Samples may become available for other scientists on request.

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11. YOPP AWIMET-PS: THE "YEAR OF POLAR PREDICTION" (YOPP): ADDITIONAL RADIOSOUNDINGS DURING THE SPECIAL OBSERVING PERIOD

H. Schmithüsen1 (not on board), D. Kenny (AWI), M. Rex (AWI)

Grant-No. AWI_PS117_11

Objectives

The „Year of Polar Prediction" (YOPP) is one of the key elements of the Polar Prediction Project (PPP, www.polarprediction.net). Its mission is:

Enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities.

Within YOPP there are three "Special Observing Periods" (SOPs) defined:

- SOP-NH1: 1 Feb. 2018 – 31 Mar. 2018 in the Arctic
- SOP-NH2: 1 Jul. 2018 – 30 Sep. 2018 in the Arctic
- SOP-SH: 16 Nov 2018 – 15 Feb 2019 in the Antarctic

To contribute to the special observing efforts of YOPP the radiosounding activity on board *Polarstern* is increased to 4 soundings per day. This follows the internationally compiled science plan of PPP[1] and the recommendations in the implementation plan[2] of the project.

Work at sea

Whenever *Polarstern* is south of 60°S, the routinely launched daily radiosounding is extended by another 3 soundings per day. Together, the soundings cover all synoptic main hours, namely 00, 06, 12 and 18 UTC.

Data management

Data management is identical to the routinely performed radiosoundings. Data on board will be made available through the DWD staff to any interested scientist. Data will be published on Pangaea after the cruise. Any scientific publication shall use the data from Pangaea.

Expected results

Radiosonde measurements are known to be one of the highest impact global observation systems for operational weather prediction analysis ("analysis" is the best guess of the status of the atmosphere at a certain point in time). Temporarily intensified soundings, together with modelling studies, are capable to quantify the impact on operational analysis products. During YOPP it is expected that the impact of polar radiosounding activities on weather prediction

capabilities can be estimated. This will give important reasoning for the optimisation of the polar meteorological observation network, which is one distinct goal of YOPP.

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12. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

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CAU	Christian-Albrechts-Universität zu Kiel Christian-Albrechts-Platz 4 24118 Kiel Germany
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Dalhousie University	Dalhousie University Biology, 1355 Oxford St, PO Box 15000 B3H 4R2, Halifax Canada
Deutscher Wetterdienst	Deutscher Wetterdienst Seeschifffahrtsberatung Bernhard-Nocht Strasse 76 20359 Hamburg Germany
HeliService	HeliService International GmbH Gorch-Fock-Straße 105 26721 Emden Germany
Hochschule Bremerhaven	Hochschule Bremerhaven An der Karlstadt 8 27568 Bremerhaven Germany

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Man-Society-Environment (MGU)	Man-Society-Environment (MGU), Dept of Environmental Sciences Vesalgasse 1 4051 Basel Switzerland
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Royal Belgian Institute for Natural Sciences	Royal Belgian Institute for Natural Sciences BEDIC, OD Nature Vautierstraat 29 1000 Brussels Belgium
Scripps	Scripps Institution of Oceanography CASPO 9500 Gilman Drive 92093 La Jolla United States
Stazione Zoologica Anton Dohrn	Stazione Zoologica Anton Dohrn Integrative Marine Ecology Villa Comunale 80121 Napoli Italy
The Marine Biological Association	The Marine Biological Association Cell and Molecular Group Cunliffe lab Citadel Hill PL1 2PB Plymouth United Kingdom

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Universität Bern	Universität Bern, Zentrum für Fisch- und Wildtiermedizin Länggass-Strasse 122 3012 Bern Switzerland
Universität Rostock	Universität Rostock Mathemathisch-Naturwissenschaftliche Fakultät Wismarsche Str. 45 18057 Rostock Germany
University of East Anglia	University of East Anglia, School of Environmental Sciences Norwich Research Park NR4 7TJ, Norwich United Kingdom
University of Southampton	University of Southampton School of Ocean and Earth Science, Waterfront Campus, European Way SO14 3ZH Southampton United Kingdom
Wageningen Marine Research	Wageningen Marine Research, Ecosystems Ankerpark 27 1781AG Den Helder Netherlands

13. FAHRTTEILNEHMER / PARTICIPANTS

Name	Vorname/ First Name	Affiliation	Beruf/ Profession	Disziplin/ Discipline
Allerholt	Jacob	Hochschule Bremerhaven	Student (BA)	Engineering
Ardiningsih	Indah	NIOZ	PhD student	Oceanography
Bertrand	Erin	Dalhousie University	Scientist	Biology
Boebel	Olaf	AWI	Scientist	Oceanography
Braun	Verena	AWI	Student (MA)	Glaciology
Castellani	Giulia	AWI	Scientist	Physics
Chamberlain	Paul	Scripps	PhD student	Oceanography
Diercks	Isabel-Katharina	Universität Rostock	Student (MA)	Biology
Droste	Elise	University of East Anglia	PhD student	Oceanography
Eggers	Sarah Lena	AWI	Technician	Biology
Eich	Charlotte	NIOZ	PhD student	Biology
Engicht	Carina	AWI	Technician	Oceanography
Enriquez	Alberto	HeliService	Technician	Aviation
Feij	Bram	NIOZ	Observer	Biology
Filun	Diego	AWI	PhD student	Biology
Fontes[2)]	René	Reederei F. Laeisz GmbH	Engineer	Shipping Company
Gischler	Michael	HeliService	Pilot	Aviation
Glemser	Barbara	AWI	Student (MA)	Biology
Gorniak	Rebecca	AWI	Technician	Biology
Graupner	Rainer	AWI	Technician	Oceanography
Hempelt	Juliane	Deutscher Wetterdienst	Technician	Meteorology
Holm	Patricia	Man-Society-Environment	Scientist	Biology
Kendzia	Jan	HeliService	Pilot	Aviation
Kenny[2)]	Darragh	AWI	Student (MA)	Meteorology
Koschnick	Nils	AWI	Engineer	Biology
Krusenbaum	Moritz	CAU	Student (BA)	Oceanography
Kühn	Susanne	Wageningen Marine Research	PhD student	Biology
Laptikhovsky	Vladimir	Cefas	Scientist	Biology
Le Paih	Nicolas	AWI	PhD student	Oceanography
Leisten-schneider	Clara	Universität Basel	PhD student	Biology
Margarita	Smolentseva	AWI	PhD student	Physics
Meijboom	André	Wageningen Marine Research	Scientist	Biology
Meiners	Klaus	Australian Antarctic Division	Scientist	Biology
Meister	Marlene	Humboldt-Universität Berlin	Student (MA)	Biology
Middag	Rob	NIOZ	Scientist	Chemistry

Name	Vorname/ First Name	Affiliation	Beruf/ Profession	Disziplin/ Discipline
Miller	Max	Deutscher Wetterdienst	Scientist	Meteorology
Milnes	Mark	Australian Antarctic Division	Engineer	Engineering
Ober	Sven	NIOZ	Engineer	Oceanography
Ossebaar	Sharyn	NIOZ	Technician	Chemistry
Pont	Sven	NIOZ	Scientist	Biology
Probst	Lewin	AWI	Engineer	Oceanography
Rex[1)]	Markus	AWI	Scientist	Physics
Richter	Roland	HeliService	Engineer	Aviation
Riginella	Emilio	Stazione Zoologica Anton Dohrn	Scientist	Biology
Rohardt	Gerd	AWI	Scientist	Oceanography
Schaffer	Janin	AWI	Scientist	Oceanography
Segner	Helmut	Universität Bern	Scientist	Biology
Spiesecke	Stefanie	AWI	Engineer	Oceanography
Tian	Hung-An	NIOZ	PhD student	Chemistry
Trace-Kleeberg	Sunke	University of Southampton	Student (MA)	Oceanography
van Dorssen	Michiel	M van Dorssen Metaalbewerking	Technician	Biology
van Manen	Mathijs	NIOZ	PhD student	Chemistry
Zäncker	Birthe	The Marine Biological Assoc.	Scientist	Oceanography
Zwicker[1)]	Sarah	AWI	Student (MA)	Biology

1) nur bis Neumayer / towards Neumayer only

2) nur ab Neumayer / from Neumayer onwards only

14. SCHIFFSBESATZUNG / SHIP'S CREW

	Name	**Rank**
1.	Langhinrichs, Moritz	Master
2.	Spielke, Steffen	EO
3.	Grafe, Jens	Ch. Eng.
4.	Kentges, Felix	EO Ladun
5.	Langer, Carl	2.Offc.
6.	Neumann, Ralph Peter	2.Offc.
7.	Rudde-Teufel, Klaus	Doctor
8.	Christian, Boris	Comm.Off
9.	Krinfeld, Oleksandr	2.Eng.
10.	Haack, Michael	2.Eng.
11.	De Bruin, Frederik	2. Eng.
12.	Redmer, Jens Dirk	Elec.Tech
13.	Ganter, Armin	Electron.
14.	Hüttebräucker, Olaf	Electron.
15.	Nasis, Ilias	Electron.
16.	Himmel, Frank	Electron
17.	Brück, Sebastian	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Bäcker, Andreas	AB.
20.	Möller, Falko	AB.
21.	Neubauer, Werner	AB.
22.	Hans, Stefan	AB.
23.	Schade, Tom	AB.
24.	Wende, Uwe	AB.
25.	Klee, Philipp	AB.
26.	Peper, Sven	Azubi 3.LJ
27.	Preußner, Jörg	Storek.
28.	Schwarz, Uwe	Mot-man
29.	Rhau, Lars-Peter	Mot-man
30.	Luckhardt, Arne	Mot-man
31.	Kreutzmann, Lennart	Trainee
32.	Gebhardt, Norman	Mot-man
33.	Köpnick, Ulrich	Mot-man
34.	Schnieder, Sven	Cook
35.	Silinski, Frank	Cooksmate
36.	Möller, Wolfgang	Cooksmate
37.	Czyborra, Bärbel	1.Stwdess
38.	Wöckener, Martina	Stwdss/KS
39.	Dibenau, Torsten	2.Steward
40.	Silinski, Carmen	2.Stwdess
41.	Golla, Gerald	2.Steward
42.	Arendt, Rene	2.Steward
43.	Sun, Yongsheng	2.Steward
44.	Chen, Dan Sheng	Laundrym.