PS112 - Weekly report No. 1 | 18.03.2018 – 27.03.2018

Course Antarctica - departure into the polar autumn

[04. April 2018]

The expedition PS112 started in the evening of the 18th of March from Punta Arenas, Chile, with 50 scientists and technicians from 7 nations on their way into the Southern Ocean. The destination: the South Shetland Island region around Elephant and King George Island at the northern tip of the Antarctic Peninsula.

The expedition revolves around three projects, which are third-party funded:

1. POSER (POpulation Shift and Ecosystem Response – Krill vs. Salps) is financed by the Ministry of Science and Culture of Lower Saxony (MWK)

2. PEKRIS (The performance of Krill vs. Salps to withstand in a warming Southern Ocean) is financed by the Federal Ministry of Education and Research (BMBF) and

3. Works under the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) framework and is financed by the Federal Ministry of Nutrition and Agriculture (BMEL).

The overarching aim of all three projects is to understand the change in population dynamics of krill and salps caused by the temperature increase in the Atlantic sector of the Southern Ocean as a result of climate change, as well as the consequences for the ecosystem.

Krill and salps are the two most common phytoplankton consuming marcroplankton organisms in the Atlantic sector of the Southern Ocean. They are, however, markedly different in their life history, feeding biology, population dynamics and their trophic position in the marine Antarctic ecosystem. Whereas krill occupies a central position in the Antarctic marine trophic web, the gelatinous salps are barely consumed. A shift in abundance and distribution between krill and salps could, given their different position in the food web, result in a cascade of short- and long-term changes in the ecosystem structure and in important ecosystem functions. Long-term studies from 1920 to 2000 have shown that the krill population is decreasing and the salp population increasing, but the reasons are still not thoroughly understood.

In this context, the focus of POSER is on the consequences of abundance shift of krill and salps on the plankton communities, their diversity and the associated biochemical cycles. PEKRIS, on the other hand, deals with the ability of both organisms to adapt to increasing sea temperatures on the basis of their physiological and genetic fitness. Few studies have investigated the effect of external stressors on krill and there are hardly any such studies on salps. With these two complimentary projects, we will try to predict the consequences of ocean warming on the salp and krill populations, and what an abundance shift would mean for the marine Antarctic ecosystem. KrillBIS represents the German contribution to CCAMLR and serves to collect abundance information of krill and salps north of the Antarctic

Peninsula. Furthermore, the abundance information enables us to extrapolate the data collected in the POSER project to larger scales and to quantify the consequences for the ecosystem.

Fig 1: Impressions from the Drake passage (Photo: Dominik Bahlburg)

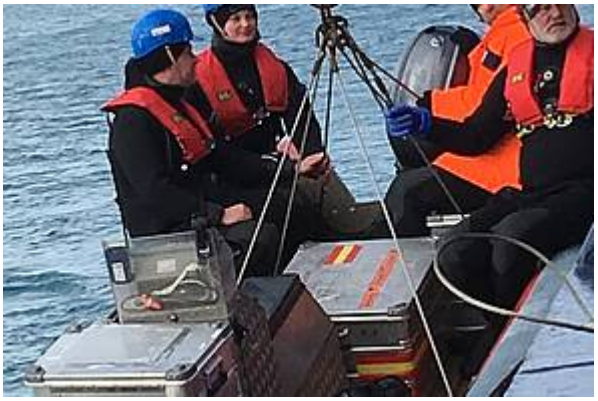

Fig 2: Scientific dive team during the first outing. (Photo: Stefanie Moorthi)

The first two days after our departure from Punta Arenas in calm waters were marked by a burst of activity consisting of organising of lab space and unpacking the countless boxes and devices. The Drake Passage soon confirmed its fierce reputation. Force 8-9 Bft winds noticeably affected the initial industriousness (Fig 1). Admiralty Bay at King George Island was reached on Thursday the 22nd of March. The first net hauls commenced outside the bay and the study organisms – krill and salps - were sighted for the first time. The integrative physiology group under Magnus Lucassen successfully deployed their fish traps. He will introduce his work in more detail in next week's report. After the first promising net hauls, we dropped anchor in the evening inside Admiralty Bay to undertake the calibration of the EK 60 echosounder the next day. This device will provide us with information on krill densities in the study area for the duration of the cruise. The scientific dive team used the time during the calibration to test their equipment under ambient conditions (Fig 2). The other research groups, which will be introduced during the coming weeks, made use of the time to complete the setup of their labs and instruments.

Fig 3: Impressions of Admiralty Bay, King George Island. (Photo: Dominik Bahlburg)

Fig 3: Impressions of Admiralty Bay, King George Island. (Photo: Dominik Bahlburg)

On the 24th of March we left the breath-taking scenery of Admiralty Bay (Fig 3) to commence with the first five legs of the CCAMLR transect. Consistent foul weather made the ship quite lively but due to the experience of the officers and crew we successfully completed the transect. In the days ahead we will complete our process studies on krill - which were initiated during the transect - in the shelter of the South Shetland Islands. In the lee of this wind-swept area, the dive team will try to catch live salps needed for the experiments with the aid of the MASMA, a custom built, diver operated plankton pump.

There is a lot of work ahead, we are in good spirits and we are looking forward to the voyage ahead.

Greetings and best wishes from a busy ship. - Bettina Meyer

PS112 - Weekly report Nr. 2 | 28.03.2018 – 06.04.2018

All around the South Shetland Islands

[09. April 2018]

After leaving Admiralty Bay the days were dominated by stormy weather.

Quite soon we needed to weather a storm with up to 12 Beaufort in the lee side of Halfmoon Island, then we turned into the shelter of Deception Island (Picture 1), where we aimed to collect alive krill and salps for the experiments aboard Polarstern. After about two weeks at sea the tension of the scientist was noticeable, everyone was awaiting their precious study animals.

Fig. 1: Deception Island. (Photo: Sacha Viquerat)

Fig 2: Fish physiologists with releaser trap. (Photo: Chiara Papetti)

Fig 3: Antarctic eelpouts at their new home. (Photo: Magnus Lucassen)

At that time we, that are Magnus Lucassen, Chiara Papetti and Nils Koschnick, felt already much comfortable. Right at the beginning of the expedition we could deploy our fish traps at Admiralty Bay (Picture 2). Two days we waited and trembled that our predictions about our target species, the Antarctic eelpout, would become true, especially, when considering that our last catch was almost nine years ago. After releasing the traps in more than 400 meter water depths by remote control we had to wait for nearly ten nerve-wracking minutes until the traps reached the sea surface. But we were really impressed after recovering the traps, more than 500 eelpouts could be retrieved alive aboard. Now they found a new home in our special aquaria container (Picture 3), which is capable of transporting Antarctic animals even at tropical temperatures across the equator. Now, we take care about the eelpouts, until our colleagues will escort them to Bremerhaven on the following cruise leg.

As members of the section Integrative Ecophysiology at AWI we investigate the evolutionary adaptation of fish and other marine animals to the extreme temperature conditions of Antarctica. Certainly, we aim to answer also the question, how these specialists may respond to the ongoing climate change, which is especially pronounced already at the Antarctic Peninsula. It turned out during our past research that the Antarctic eelpout serves as a good model system to answer these fundamental questions. But surely, the Antarctic fish fauna is very diverse, and therefore another topic of our cruise will be the characterisation of the fish fauna at the Antarctic Peninsula and the collection of samples from diverse fish groups for ongoing genetic studies. This is the main research area of our team member, Chiara Papetti, from the University of Padova. Together with her we would also like to learn more about the Antarctic toothfish, which is due to its size and the market prize of high economical interest. As one of the longest-living fish in Antarctica and late maturity it might be particularly endangered, when commercial fishery becomes permitted.

Back to Deception Island: Here our colleagues were finally successful and could catch alive krill and even the extremely fragile salps for their experiments aboard. About these experiments we certainly hear more during the next weeks. After having a nice Easter at Deception Island thanks to the excellent dishes, but without searching for Easter eggs, we passed the Southern tip of the South Shetland Islands on Monday and turned back to the Drake Passage. From there we moved in a zigzag line along the North-Western side of the islands towards the North, to complete the next CCAMLR transect (Convention for the Conservation of Antarctic Marine Living Resources). On the shelf, these transects were interrupted by our bottom trawls for catching fish. Facilitated by unusual good weather conditions in the Drake Passage we proceeded fast, and so we will reach Elephant Island at this weekend. Here, further process studies on salps and krill will be the focus for the upcoming days. More about this will follow soon.

With best wishes from Polarstern on behalf of the chief scientist, Bettina Meyer and all participants,

Magnus Lucassen

PS112 - Weekly report No. 3 | 8 - 14 April 2018

Salps, krill, and Elephant Island

[17. April 2018]

The past week we have spent studying the waters around Elephant Island. Although this region is known for its harsh weather conditions we have been lucky and were able to continuously carry out our scientific experiments. The mood on board is very good and all working groups have made decent progress. .

Our whale observers have been particularly happy about the stopover at Elephant Island where we have seen large aggregations of feeding Finwhales, an indication for the presence of krill. We have caught enough krill and salps to satisfy all the scientists who need large amounts of both species for their experiments. We were a bit worried about getting enough salps, as 2018 was not predicted to be a year with high salp abundance, but to cite Evgeny Pakhomov, our salp expert: “This is supposed to be a bad salp year? I would not like to be around during a good salp year!”.

We observed high abundance of whales, salps, and krill along the northern part of Elephant Island, however, we observed a low chlorophyll concentration of 0.2 mg per cubic meter. This suggests that there must have been considerable grazing activity on the phytoplankton by both krill and salps. Now we are leaving the area to spend the next week in the south in the Weddel Sea east of the Antarctic Sound. It will be interesting to see how the situation around Elephant Island has progressed in one week’s time when we are returning. The whales have now started their extensive grazing on the krill in the northern region off Elephant Island. Will this reduce the krill and allow the phytoplankton to grow to higher abundances or will the salps take over and continue the intensive grazing on the phytoplankton?

It goes without saying that if one eats a lot one poos a lot. Especially krill and salps eat a lot in Antarctica and therefore we have a special interest in their fecal pellets. We have a whole team focusing on the sinking of krill and salp fecal pellets. The team consists of Clara Flintrop, Nora-Charlotte Pauli, Christian Konrad, Evgeny Pakhomov, Larysa Pakhomov, Christian Konrad, and Morten Iversen. The sinking of particles such as fecal pellets through the water column controls carbon dioxide removal from the atmosphere. The falling particles feed life below the ocean’s surface and sustain the biomass of deep sea fish and other organisms. The amounts of material that reach the seafloor depends on how the particles are transformed via microbial activity and grazing by zooplankton as they fall.

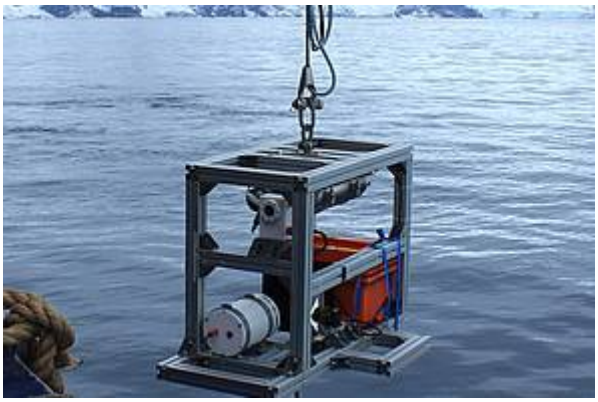

Fig 1: In Situ Camera off Elephant Island. (Photo: Morten Iversen)

Fig 2: Drifting sediment trap off Elephant Island. (Photo: Nora Pauli)

Fig 3: Kreisl with krill in the cooling container. (Photo: Clara Flintrop)

Traditionally, we have collected all particles as bulk material in sediment traps. However, this does not address the mechanisms that control the export and turnover of material as it sinks through the water column. Examining the particle size-distributions in conjunction with measured fluxes and zooplankton distributions and behavior provides a powerful new approach to the understanding of carbon flow. To accomplish this we are combining careful mapping of the abundance and horizontal and vertical distribution of krill and salps with detailed studies of their grazing and fecal pellet production rates. This approach provides us with a clear understanding of how much suspended phytoplankton is packed into large, fast-sinking fecal pellets for each study region. We are using camera profiles (Photo 1) and modified sediment traps (Photo 2) equipped with a viscous gel that preserves the size, shape, and structure of all sinking particles, including the fragile fecal pellets from salps and krill. In this way we can determine the proportion of fecal pellets that will fall all the way to the seafloor, the proportion that will be re-processed by either microbes or zooplankton in the water column. To understand the role of microbes and zooplankton for the turnover of sinking fecal pellets we are measuring size-specific sinking velocities, microbial respiration, and biogeochemical composition of the pellets in the laboratory. Additionally we brought large

cylindrical aquariums called ‘Kreisel’ (Photo 3) in which we video record the feeding behaviour of both krill and salps when offered a diet of their own fecal pellets. All recordings are illuminated with infrared light to emulate their nightly foraging conditions in the ocean surface waters. With these studies we hope to understand the fate of krill and salp fecal pellets in Antarctica.

One may ask why it is interesting to study the waste products of krill and salps. The answer is closely linked to recent discoveries of a shift from krill to salps in the Southern Ocean. Currently we do not know the consequences of such a shift for the ecosystem structure and function. Salps are known as non-selective feeders that graze on anything from the size of one bacterium up to the largest particle that can fit through its mouth opening. This means that more phytoplankton might be packed into large, rapidly sinking salp fecal pellets compared to krill fecal pellets, and a shift from krill to salps may enhance the carbon flux and the efficiency of the biological carbon pump. A shift from krill to salps may also channel less primary production to the large pelagic, krill feeding whales. It is therefore important to study the waste products of krill and salps because it will tell us what the future of the large marine mammals in the Southern Ocean might look like. Our studies will also tell us how the carbon sequestration in the Southern Ocean will function after a shift from krill to salps.

We are currently steaming towards the Weddel Sea to look for the krill spawning grounds and to find krill larvae. Our hope is that we will mainly find krill in these southern, cold waters and that we acquire a better understanding of the export and turnover processes in an ecosystem dominated by krill. By comparing the results with those obtained in the salp dominated system around Elephant Island we will learn a lot about the influence of salps on the ecosystem structure and the export of carbon.

With best wishes from Polarstern on behalf of the chief scientist, Bettina Meyer and all participants,

Morten Iversen

PS112 - Weekly report No. 4 | 15 - 21 April 2018

Krill, seals and humpack whales in the Weddell Sea

[23. April 2018]

The last week, we spent in the waters around the northern tip of the Antarctic Peninsula. We have been really lucky again regarding the weather and, in addition to our scientific endeavors, spent some wonderful sunny days in the ice around Joinville Island and the Peninsula.

After four working weeks, we celebrated our slightly delayed "Bergfest" on Sunday with a great barbecue on deck. The chef had prepared a great selection of meat (including antelope steaks!), tofu, veggies and salads and everybody had a good time.

Fig 1: Adelie Penguines on an ice floe. (Photo: Dominik Bahlburg)

Our scientific program resumed the next morning. It focused on two bottom trawls of the Integrative Ecophysiology group (AWI) to catch specific deep-sea fish for physiological analyses (their work has been described in more detail in the second weekly report). At the same time, we had the pleasure to enjoy a very sunny day and great scenic views along the coastline. In the distance, we saw some fur seals, Adelie penguins (Photo 1) and even a leopard seal on some ice floes.

The Plankton Ecology Group from the ICBM, University of Oldenburg, consisting of Dominik Bahlburg, Philipp Wenta, Christoph Plum and Stefanie Moorthi, focuses on the influence of the two key grazers, Antarctic krill (*Euphausia superba*) and salps (*Salpa thompsoni*) (Photo 2), on the lower food web in the plankton community.

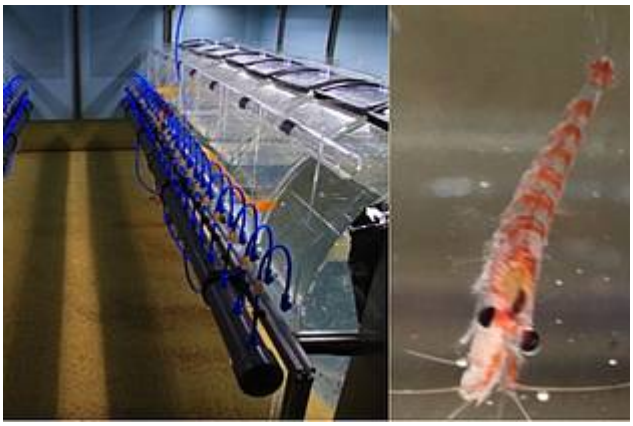

Fig 2. Krill and salps in our aquaria situated in a constant-temperature container. (Photo: from left to right: Christoph Plum, Stefanie Moorthie, Philipp Wanta.)

Fig 3: Bongo net. (Photo: Stefanie Moorthi)

Based on pronounced differences between these two grazers in feeding, growth, reproductive cycles and internal structure / composition with regards to carbon-, lipid- and protein content, we also expect different impacts on the plankton community. On this cruise we combine field studies with experimental manipulations on board in order to investigate a whole suite of factors controlling plankton dynamics and export in patches with high krill or salp abundances. We take water samples from 4 depths at different onshore and offshore locations to characterize plankton biomass and community structure (bacteria, phyto- and zooplankton of different size classes), as well as the biochemistry of the water (dissolved nutrients and organic carbon). In addition, we take Bongo net tows to collect and characterize mesozooplankton (0.2 - 2mm, Photo 3).

All of these data will be related to krill and salp abundances in the water column determined by net tows as well as to the respective hydrographic conditions.

Furthermore, we conduct on-board experiments with krill and salps. Whereas krill is quite robust to be used in experimental manipulations, salps are very sensitive and fragile and have to be handled with a lot of care. So far, very few experiments have been conducted with *Salpa thompsoni* in the Southern Ocean and we are very happy that we were able to collect salps alive and in good physiological condition at Deception and Elephant Islands. We conducted two large experiments with them so far, one of which is still running. In both, we incubated krill and salps alone and in combination (salps and krill) with a natural plankton community in cylindrical aquaria that we brought with us (70 liters, Photo 2). During the first experimental period, we investigated direct grazing effects on plankton biomass and community structure, as well as effects on nutrient recycling and carbon export. The treatment combining krill and salps will enable us to study interactive effects of these two major grazers, which co-occurred in the natural habitats sampled at Deception and Elephant Islands. After 4-5 days, we filtered the water preconditioned by krill and salps to remove all of

the organisms and incubated a fresh phytoplankton assemblage. Salps and krill presumably recycle nutrients in different amounts and ratios, which may indirectly affect phytoplankton biomass and community structure. In comparison with large-scale observations in the field, our experiments allow us to disentangle and quantify direct and indirect consequences of potential grazer shifts from krill to salps for the plankton community structure and process rates within the food web.

As expected, we did not find *Salpa thompsoni* further south, but we found lots of krill. The Krill group (AWI) led by Bettina Meyer, investigated the relationship between the bottom topography west off the Antarctic Sound and the respective hydrography and krill abundance and distribution. High krill abundances were observed above the numerous seamounts characterizing this region. Moreover, they conducted krill growth experiments, which are a good indicator of food availability and the fitness of krill.

The Biological Carbon Pump group, led by Morten Iversen (AWI/Marum, Bremen), conducted a 24-hour camera survey of the water column during which they deployed their camera system every six hours to obtain a more detailed insight into the vertical night-day migration of krill and their fecal pellet production. Additionally, they were able to conduct another experiment to assess the fecal pellet production of krill over time, as well as the carbon content of these pellets.

Wednesday morning, we had wonderful weather conditions and a lot of humpback whales came very close to the ship, including a mother-calf pair. Our whale survey group led by Helena Herr (University of Hamburg) had covered the Antarctic Sound the same morning by helicopter and recorded many sightings of humpback whales. In the afternoon, we left this southernmost region of our research transect through an, unfortunately, very foggy Antarctic Sound, to reach our last East transect, northbound, on the southern side of Elephant Island. We are looking forward to find out what conditions will prevail there, compared with the northern side, in terms of krill and salp biomass and distribution, and also regarding fin whale abundance. We hope to fill some last gaps in our experiments and process studies and cannot yet imagine that we will have to pack right afterwards to start our voyage back home.

With best wishes from Polarstern on behalf of the Chief Scientist, Bettina Meyer and all participants,

Stefanie Moorthi

PS112 - Weekly report No. 5 | 22nd April – 2nd May 2018

Of Fin Whale aggregations, trace metals and the end of the expedition

[02. May 2018]

We have now entered the last phase of our expedition. After spending a week surrounded by sea- and glacier ice south of the West Antarctic Peninsula we have arrived back at Elephant Island, where we will spend the remaining time of the expedition before heading back to Punta Arenas.

Sheltered from heavy winds by Elephant Island, we have started our fourth and final process study, which, once again, required a large amount of healthy salps and krill. The effort to collect animals was unfortunately hampered by the rough sea state and thus, on the only calm day, the divers were called into action. Using various techniques, they collected hundreds of salps and brought them back to the ship, ensuring that the last round of experiments could be started.

Fig 1: The Whale Survey Team, Sacha Viquerat (left) and Helena Herr (right) with Bertie Gregory (center) (Photo: Abigail Lees)

Fig 2: Fin whale feeding aggregation at Elephant Island. (Photo: Helena Herr)

Returning to Elephant Island and spending the remaining research time of the expedition here was also fortunate for the whale survey team (Photo 1). During our first stay at Elephant Island we encountered high numbers of fin whales – the target species of the fin whale abundance project, headed by Helena Herr from the University Hamburg. Fin whales were the most severely hunted whale species during the times of commercial whaling in the

Southern Ocean. Their numbers were reduced to about 2% of their pre-whaling population size. Until today, their recovery status is not well established. Fin whales are fast swimmers which spend most of their time far offshore. This trait makes them difficult to study. Over the past few years, high fin whale sighting rates have been reported from the Western Antarctic Peninsula (Photo 2), along with an increase in acoustic detections. Therefore, the aim of the whale surveys is to map fin whale distribution throughout the study area of the expedition. We want to estimate the number of fin whales in the area and investigate drivers for their distribution. We are particularly interested in their relationship between whale and krill distribution. This expedition provides an excellent opportunity to map krill and whale distribution at the same time and to compare the patterns. Data on whale distribution are collected via helicopter surveys, which enable the whale survey team to cover the krill survey transects. By using helicopter surveys, long distances can be covered during short time-windows of feasible conditions. Moreover, data on whales can be collected at a distance from the ship, without influencing distribution patterns e.g. by acoustic disturbance from the ship. For the visual observations during the flights, however, calm weather and good visibility are required – conditions which are quite rare in this part of the world, especially now, in austral autumn. Due to time and weather limitations, our first stay at Elephant Island had left some gaps in the survey coverage. During the past few days, the whale survey team managed to fill these gaps and successfully completed their survey.

Fig 3: The Trace Metal Group: Sebastian Böckmann, Florian Koch, Franziska Pausch, Dorothee Wilhelms Dieck and Anna Pagnone (from left to right). (Photo: Nora Pauli)

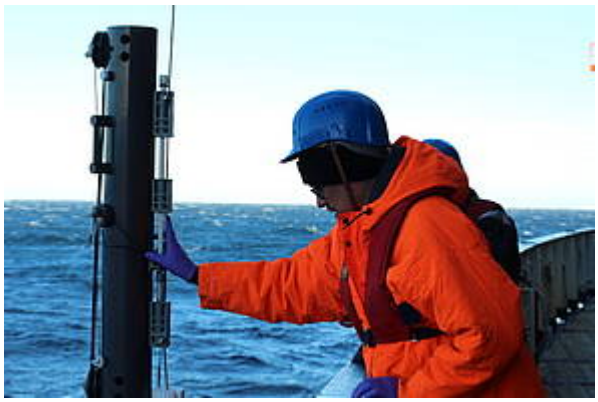

Fig 4: Florian Koch deploying the GoFlo. (Photo: Nora Pauli)

It seems that the large aggregations of fin whales are sustained by krill, which in turn feed on phytoplankton. In many regions of the Southern Ocean, however, trace elements such as iron limit primary production. The goals of the trace metal group on board (Photo 3), led by Florian Koch, are to elucidate the impact of iron limitation and trace nutrient (iron, zinc, and vitamin B12) cycling around the waters of the Western Antarctic Peninsula. In addition, the impacts of salp and krill fecal pellets and various dust sources on trace metal concentrations and their bioavailability are being investigated. Since the Polarstern consists of 11,820 tons of metal, special care needs to be taken not to contaminate the samples. A Teflon membrane pump, connected to a polyethylene line was used to pump surface seawater from 20 m depth directly into a trace metal clean container where the seawater could be sampled. Over a period of 6 hours, ~3000L of clean seawater were pumped onto Polarstern. Three stations, one in off-shore high nutrient low chlorophyll (HNLC) waters, and two in coastal low chlorophyll regions, were sampled in this manner and a total of ten experiments with this water were conducted,

looking at the impacts of fecal pellets, dust and grazing on phytoplankton/trace metal dynamics. Another way to collect water using ‘trace metal clean techniques’ is via a specialized collection bottle called a ‘GoFlo’ (Photo 4). Unlike regular bottles on a CTD Rosette, which enter the water in the open position and are closed at depth, a ‘GoFlo’ has a specialized mechanism. This enables the bottle to enter the water in the closed position and minimizes contamination from the ship. Using the ‘GoFlo’, water was collected at ten stations in order to measure trace metal and vitamin removal and recycling processes with the help of isotopic tracers. Radioisotopes are a powerful tool to measure various rate processes in the marine environment and the Polarstern has a state of the art isotope container in which these compounds can be safely used. Concurrently, bacterial production and primary production rates were assessed and water samples collected in order to characterize the plankton community composition as well as the water chemistry (trace metals, ligands, nutrients, vitamins).

On the 30th April we finished our activities at our last process study station and left Elephant Island in northerly direction in order to complete our krill and salp abundance transect. At present all working groups are busy packing their scientific equipment and organizing the storage of the scientific samples that were generated during the expedition. Everybody hopes for a smooth crossing of the Drake Passage in moderate weather conditions because this area is notorious for the high frequency of low pressure systems.

PS112 was a very successful expedition. For the first time, experiments were conducted with the salp species Salpa thompsoni in pristine condition, their interaction with the Antarctic krill Euphausia superba as well as the impact of both organisms on the biological carbon pump and the phytoplankton composition. In addition, we were able to observe a large fin whale aggregation and their foraging behavior on krill, which was not observed before. We are looking forward to analyze the large dataset and the hundreds of samples that were generated during the expedition at our home institutes and to combine the results fulfill the aims of our projects.

With best wishes from all expedition participants from Polarstern

Helena Herr, Florian Koch, and Bettina Meyer (Chief Scientist)