14. UNDER-ICE FAUNA, ZOOPLANKTON AND ENDOTHERMS

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Objectives

The Arctic Ocean is facing drastic changes, most evidently a significant decline of the extent and duration of sea ice coverage. This process is accompanied by ocean warming in some areas of the Arctic Ocean, and increasing acidification. A reduction and change of sea ice habitats will have consequences on ecosystem functioning since, at high latitudes, ecosystems thrive on carbon produced by ice-associated algae. Grazers in the ice-water interface layer, such as under-ice amphipods and copepods, as well as young polar cod *Boreogadus saida* feeding on them, play a key role in transferring sea ice-derived carbon into pelagic food webs, and ultimately to the birds and mammals inhabiting the Arctic (Kohlbach et al. 2016, in press). Reduction of sea ice habitats may result in insufficient resources for juvenile polar cod and in a potential loss of connectivity between central Arctic sea ice habitats and shelf-based populations (David et al. 2016). Further decline and structural change of Arctic sea ice may thus lead to habitat loss and reduced food availability for this fish. A major decline of polar cod stocks can cause severe ramifications in Arctic ecosystems, and can particularly affect populations of higher predators, such as seals and polar bears *Ursus maritimus*. Our group aims to better understand potential impacts of changing sea ice habitats for polar cod, its prey, and its predators.

During PS106.2, we will sample the physical and biogeochemical habitat properties and biodiversity of the sea-ice associated habitat, with an emphasis on polar cod and its ice-associated and pelagic prey species. The abundance and distribution of under-ice fauna is poorly understood due to the inaccessibility of the under-ice habitat. New sampling methods are therefore warranted to observe and quantify this important functional group of the food web, and its resilience to changing sea ice habitats. To investigate the vertical and horizontal distribution and abundances of abundant zooplankton and under-ice fauna species, meso- and macrofauna will be sampled with a Surface and Under-Ice Trawl (SUIT), a Rectangular Midwater Trawl (RMT), a Multinet, an ROV-mounted under-ice net, echosounders (*Polarstern's* EK60/80 and Acoustic Zooplankton and Fish Profilers, AZFPs), and an acoustic imaging camera. With the zooplankton recorder LOKI (light frame on-sight key species investigator, Fig. 14.1), we will continuously take pictures from the organisms floating in the water column from 1,000 m depth to the surface and during horizontal ROV-transects, which allows to exactly identify horizontal and vertical distribution patterns in relation to environmental conditions.

Polar cod constitutes the staple food of various Arctic and North-Atlantic bird and seal species, thereby indirectly ensuring food sources of polar bears. To assess the relevance of sea ice-associated resources and polar cod for higher trophic levels, endotherm surveys will

be conducted to map the association of seabirds, polar bears, seals and whales with the distribution of polar cod and sea-ice habitat properties.

Work at sea

Under-ice sampling

The association of polar cod and other under-ice fauna with sea ice properties and various environmental parameters will be investigated with a Surface and Under-Ice Trawl (SUIT: van Franeker et al. 2009). The SUIT has two nets, a 0.15 mm mesh plankton net, and a 7 mm mesh shrimp net. During SUIT trawls, data from the physical environment are recorded, e.g. water temperature, salinity, fluorescence, ice thickness, and hyper-spectral light transmission. SUIT deployments will be conducted at regular intervals along the SiPCA transects.

During PS 106.1 and during sea ice stations of PS 106.2 we will study the horizontal and vertical distribution of meso- and macrofauna using various innovative and experimental approaches:

- An Acoustic Fish and Zooplankton Profiler (AZFP) will be deployed close to the biological sampling sites to determine the vertical distribution of zooplankton and fish under the sea ice with high temporal resolution;
- The ROV of the sea ice physics group will be used to sample under-ice macrofauna with a zooplankton net scraping the underside of sea ice;
- A LOKI will be mounted on the ROV to sample the horizontal distribution of mesozooplankton in the ice-water interface layer;
- An acoustic imaging camera will be deployed under the ice to observe and monitor the habitat use of polar cod Boreogadus saida.

Pelagic sampling

Particulate Organic Matter (POM) will be collected from filtered seawater obtained from the CTD rosette. Chlorophyll samples will be filtered from CTD rosette water samples to calibrate fluorometers built in the ship's CTD and the SUIT.

Mesozooplankton composition and depth distribution will be determined by means of vertical Multi net tows from 1,000 m depth to the surface. In addition, optical surveys with the LOKI will be conducted to determine the small-scale distribution of zooplankton in the water column. We will also mount an acoustic backscatter system (Aquascat, equipped with 0.3, 0.5, 1, 2 and 4 MHz transducers) on the LOKI. This will allow for parallel sampling of optical and acoustical data. Bongo net hauls will be taken to collect organisms for biochemical analyses and trophic biomarkers (stable isotopes, carbon, nitrogen, protein and lipid content, fatty acid composition).

A Rectangular Midwater Trawl (RMT) will be used to sample deeper-dwelling key species of the pelagic food web, such as euphausiids, amphipods, and fishes down to 200 m water depth. The RMT consists of a 1 m^2 opening 0.3 mm mesh mesozooplankton net mounted on top of a 5 mm mesh macrozooplankton net. In addition, *Polarstern's* EK60/80 echosounder will be running during steaming to map the distribution of fish and macrozooplankton in the water column continuously.

Organisms caught with nets will be sampled and stored in formalin, -80°C and -20°C, and will be studied further using microscopy, DNA analysis, calorific content analysis and C/N ratio analysis.

Biomarker analysis

The trophic significance of ice algae in Arctic pelagic food webs will be investigated with molecular and isotopic biomarkers (see chapter 12, 13). To this end, organisms caught with SUIT, RMT and other gear will be sampled and stored at -80°C, and later submitted to compound-specific stable isotope analysis (CSIA) at the AWI. To sample the trophic baseline needed for the interpretation of CSIA results (ice algae and phytoplankton), melted sea ice cores and seawater samples will be filtered.

Diet analysis

To further investigate the significance of ice algae in the diet of under-ice fauna, and the significance of under ice fauna in the diet of polar cod and top predators, stomach contents and energy content of trophic key species will be investigated. To further link the sea ice food web components, we will conduct DNA analysis of the stomach contents of under-ice fauna including *Boreogadus saida*, and compare those to traditional stomach content analysis and trophic markers.

Top predator censuses

Quantitative censuses of top predator community (seabirds and marine mammals) will be conducted in the study area and on transects to and from the study area. This will be a combination of ship-based and helicopter-based surveys. Ship based censuses are conducted from the moving ship from two special outdoor observation posts that are attached to the front guard-rail of the Peildeck of *Polarstern*. Bird densities are assessed by band transect surveys with snapshot methodology for individuals in flight (Tasker et al. 1984). For marine mammals, viz. seals, polar bears and whales, line-transect methodology is added (Buckland et al. 2001). Allometric formulas based on body mass are used to translate density data for individual species to energy and food requirements per surface area (van Franeker et al. 2002).

Preliminary (expected) results

Post-expedition analysis of biological samples will comprise diet analysis, trophic biomarker analysis, otolith studies, and genomics. The resulting datasets will enable us to

1. identify sea ice habitats favourable for polar cod in terms of physical properties, prey availability and biodiversity;
2. quantify the carbon flux between sea ice, pelagic communities, polar cod and top predators;
3. study the connectivity between central Arctic under-ice populations of polar cod and shelf-based spawning stocks;
4. identify critical habitats for the viability of polar cod stocks and marine endotherms, and assess their vulnerability to climate change.

Furthermore, we expect to obtain a comprehensive dataset of the distribution and diversity of pelagic and under-ice fauna of the Arctic Ocean and their relationship with the sea-ice habitat.

Data management

Almost all sample processing, such as chemical measurements and species identifications and quantifications, will be carried out in the home laboratories at AWI and Wageningen Marine Research. As soon as the data are available they will be accessible to other cruise participants and research partners on request. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA, and will be open for external use.

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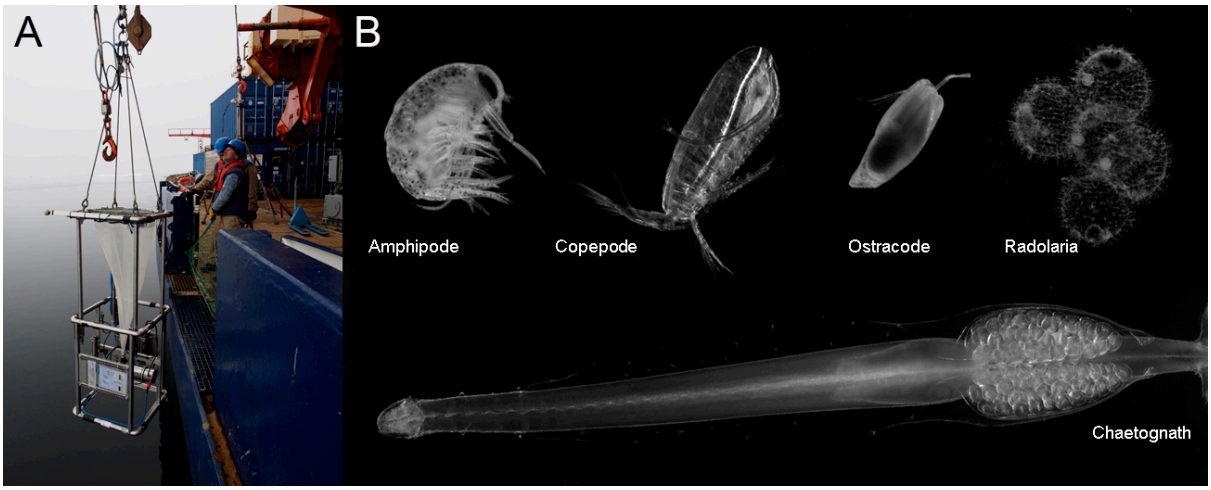

Fig. 14.1: the LOKI system during deployment (A, ©Martin Doble, PolarScientic) and a compilation of photographs taken by LOKI (B, ©N. Hildebrandt, AWI).

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HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS106

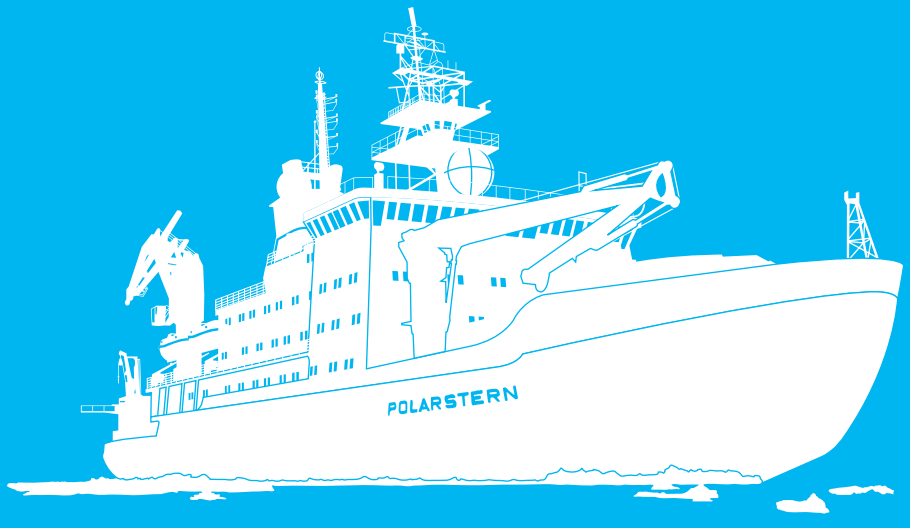
Polarstern

PS106.1
Bremerhaven – Longyearbyen
23 May 2017 - 21 June 2017

PS106.2
Longyearbyen - Tromsø
23 June 2017 - 20 July 2017

Coordinator: Rainer Knust

Chief Scientists: PS106.1 Andreas Macke
PS106.2 Hauke Flores



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