Summary of RV Maria S. Merian Trans-Atlantic Cruise

March 20 – April 16 2013

EURO-BASIN Annual Meeting // October 2013 // Istanbul
Cruise participants

Scientists from AWI, DTU Aqua, NOAA, PML, UHAM and UiN
Background & Cruise track

- MSM26 part of an international multi-vessel campaign within the EURO-BASIN project from Cork (Ireland) to St. Johns (Canada)

- Broad scale survey of North Atlantic pelagic ecosystem & targeted process studies in different habitats // water mass characteristics
Sampling gear

- Focus on lower trophic levels from phytoplankton to micronekton

- Physical and biological samples were taken at each station using the following instruments:
  - CTD-rosette
  - Optical instruments: VPR / LOPC / LISST
  - Multiple opening and closing nets: MOCNESS / MultiNet
  - Integrating nets: WP2 / IKMT

- In between stations a high-speed multi-sensor platform (TRIAXUS) was towed equipped with CTD, LOPC, Turner, Acoustics (200khz & 333khz), oxygen and turbidity sensors.
• CTD casts down to 2000 m (depth limit of PAR-sensor) and flow field measurements down to 700 m and 300 m depth by two shipmounted 75kHz and 38 kHz Acoustic Doppler Current Profiler (ADCP)

• Major sampling sites located in the Icelandic Basin (black), Irminger Basin (blue) and Labrador Basin (red)
Hydrography (Theresa Reichelt / UHAM)

- Deep convection down to 600m in Iceland Basin
- No deep convection west of Reykjanes Ridge
- High eddy-activities
Black: Iceland Basin, blue: Irminger Sea, red: Labrador Basin
MNAW = Modified North Atlantic Water,
DSOW = Denmark Strait Overflow Water,
ISOW = Iceland Scotland Overflow Water,
LSW = Labrador Sea Water
Nutrients & Phytoplankton (Bettina Walter / UHAM)

- **Nutrients:**
  Sampled at every station, 10 depth between 0 – 1000 m
  (Nitrate, Nitrite, Phosphate and Silicate) Frozen samples will be analyzed via Auto-analyzer at the HZG (Helmholtz-Centre-Geestacht)

- **Phytoplankton:**
  Sampled at every station, 5 depth between 0 – 100 m
  Chlorophyll \(a\) analyzed with fluorometer
  Lugol samples: for specification and determination of biovolume (to be done)
  Pigment analysis (HPLC end of this year)
• Samples for abundance and species estimation collected with 55 µm Multinet – under process

• Water samples taken from chlorophyll maximum at each station, grazing dilution experiments conducted following Landry & Hassett (1982)

**Dilution experiments**
- Example Stations 2 (Icelandic basin) & 12 (Labrador basin)
- chlorophyll $a$ concentrations at station 2 lower (0.2 µg Chl $a$ L$^{-1}$) than at station 12 (0.6 µg Chl $a$ L$^{-1}$)
- higher growth (0.503 d$^{-1}$) & grazing rate (0.013 d$^{-1}$) at station 2 than at station 12 (0.452 d$^{-1}$;0.006 d$^{-1}$)
- Generally, the preliminary results show a heterogeneous pattern so far

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**Figure:** Phytoplankton growth rates [$\mu$; d$^{-1}$] at different dilution levels [%]. Results for station 2 shown in white, for station 12 in black.
Temperature experiments
- Example Stations 2 (Icelandic basin) & 8 (Irminger basin)
- *in-situ* temperature at station 2: 9.1°C, at station 8: 8.5°C
- no algae growth observed; experiments have been performed in complete darkness
- no temperature effect visible

- Stations 2 & 8 show similar results for grazing on algae without copepods **BUT** with:
  - Station 2: less grazing (indicating *grazing of copepods on microzooplankton*, which in turn releases grazing pressure from the algae)
  - Station 8: more grazing on algae (indicating even more grazing pressure on algae potentially because of too low concentrations of microzooplankton to serve as prey for copepods)

*Figure 2*: Phytoplankton growth rates [$\mu; d^{-1}$] at different temperatures [$^\circ C$]. Results for station 2 shown in white (circles – without copepods, triangles – with copepods), for station 8 in black (circles – without copepods, triangles – with copepods).
Overall, particle sizes ranging from 2.5 to 500 microns showed cross transect variability in total concentration. Daytime casts in the Iceland Basin (1, 2, and 6) had higher concentrations of particles from 25 to 75 microns in size. Other particle size classes, and nighttime casts in general were more variable.
Differences and similarities in mesozooplankton distribution across the North Atlantic

Objectives
- Identify differences in the vertical distribution of mesozooplankton within North Atlantic basins
- Analyse factors that determine the vertical distribution during spring
- Provide data for analyses of trophic state and productivity, based on biovolume spectrum theories

Methods
- 9 stations across the North Atlantic, focusing on basins east and west of the Mid Atlantic Ridge
- Vertical profiles from 2000/1000 m to surface sampled by LOPC-CTD-F
- 21 deployments during day and night
- Particle analyses based on size and transparency, and calibrated based on net samples
Differences and similarities in mesozooplankton distribution across the North Atlantic

Mesozooplankton: LOPC (Sünnje Basedow / UiN)
Mesozooplankton: VPR (Klas Möller/ UHAM)

- 60 Vertical day & night profiles
- 24x24mm magnification
- Calibrated image volume 44.72ml

- Color camera, 20Hz, 1028x1024pixel, CTD, 1000m depth rating / Battery pack: 2.5 hours of continuous operation

Objectives:
- the vertical distribution, taxonomy and size structure of zooplankton & particles in different hydrographic regimes
- The diapause depth of C. finmarchicus in relation to deep convection
- Individual interactions between zooplankton consumers and sinking particles
Contrary to LOPC: All Calanus still below convective depth

Same pattern as observed in 2012
Mesozooplankton: VPR (Klas Möller/ UHAM)

- Calanus migrating upwards, a minor portion still hibernating
- Indication of Diurnal Vertical Migration (DVM)
- Copepods attached to Marine snow aggregates
- Increase of species & abundance from east to west
Objectives:
- Support optical sampling methods
- Ground truthing of taxonomic identification
- Biomass estimations
- Collecting samples for biochemical analysis and micronekton

Method:
- 1m² D-MOCNESS with 20 nets (335µm mesh) and CTD
- Day- and nighttime hauls towing with 2 knots
- 1 net side preserved, other side for experiments etc

Data:
No detailed analysis has been performed yet. Manual taxonomic identification and biomass & size estimations with a Zooscan will be performed at UHAM beginning of next year
Focus = response to increased temperature in short term (3 h) and long term (6 day) exposures

Method: Incubations at 0, 5, 10, 15 & 20°C in filtered seawater fed with Thalassiosira weissflogii

Results: Every 48h

- Faecal pellet production – index for grazing
- Egg production – index for growth

Results: End of experiment

- Copepods preserved in RNAlater for transcriptomic analysis
Vital rates of *Calanus finmarchicus* (R. Harmer / PML)

**Results**

Grazing rates and mortality

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Percentage alive and dead after 6 days</th>
<th>Mean fecal pellet production (grazing rate) amongst females after 2, 4 &amp; 6 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 °C</td>
<td><img src="pie_chart_0C.png" alt="" /></td>
<td><img src="bar_chart_0C.png" alt="" /></td>
</tr>
<tr>
<td>5 °C</td>
<td><img src="pie_chart_5C.png" alt="" /></td>
<td><img src="bar_chart_5C.png" alt="" /></td>
</tr>
<tr>
<td>10 °C</td>
<td><img src="pie_chart_10C.png" alt="" /></td>
<td><img src="bar_chart_10C.png" alt="" /></td>
</tr>
<tr>
<td>15 °C</td>
<td><img src="pie_chart_15C.png" alt="" /></td>
<td><img src="bar_chart_15C.png" alt="" /></td>
</tr>
<tr>
<td>20 °C</td>
<td><img src="pie_chart_20C.png" alt="" /></td>
<td><img src="bar_chart_20C.png" alt="" /></td>
</tr>
</tbody>
</table>
Vital rates of *Calanus finmarchicus* (R. Harmer / PML)

**Temperature**

Percentage *spawning females* and *not spawning* on day 6

Mean egg production amongst *spawning females* after 2, 4 & 6 days

Mean egg production amongst *all females* after 2, 4 & 6 days

**Results**

**Egg production**

- **0 °C**
- **5 °C**
- **10 °C**
- **15 °C**
- **20 °C**
Still to come…..

Transcriptomic analysis:
Galice Hoarau- Nordland University
Transcriptome reflects the genes actively expressed in an organism at a given time.
• How does temperature stress affect gene expression?
• How adaptable are *C. finmarchicus* to temperature changes?

More experiments:
Plymouth - determine Southern limit of distribution of *C. finmarchicus*
Background
Bachelor project, University of Copenhagen

Aims
Investigation of in situ and temperature related grazing rates of *Calanus finmarchicus*, and evaluate this also a through simple grazing model

Measurements and experiments
Chlorophyll *a*
Chlorophyll *a* was measured at diff. water depths at each station

*In situ grazing rates:*
In deck mounted basin with temperature regulated with seawater female *C. finmarchicus* were incubated individually 24h in experimental bottles with sampled water.
As a proxy for grazing fecal pellet production was counted, and mean volume measured to estimate carbon content
Also prosome length of incubated *C. finmarchicus* was measured to estimate carbon content

*Egg production:*
Egg production was counted, and mean volume measured to estimate carbon content

*Temperature response:*
Individual *C. finmarchicus* fecal pellet production was monitored in temperature response experiment conducted by Rachel Harmer during the cruise
Experimental temperatures were approximately 0,5,10,15 and 20 °C
**Grazing predictions:**
Grazing, here expressed as specific ingestion (SI) can be regarded as being dependent on temperature and food concentration (here Chl a) (Møller et al., 2012).

**Specific ingestion (SI):**
SI of the experimental animals were estimated from calculated C.fin and fecal pellet carbon content, assuming assimilation efficiency of 65% (Thor and Wendt, 2010).

**Grazing dependency on temperature:**
The dependency of grazing on temperature was found by fitting the temperature response results with an equation relating physiological rates with temperature (Kooijman, 2000; Schoolfield et al., 1981).

**Grazing dependency on food concentration:**
Ingestion dependency on food concentration was described by a type III functional response (Gentleman and Neuheimer, 2008). Parameterization by non-linear least square fitting to obtained in situ grazing rates corrected for temperature differences.

**Preliminary results:**

*C. finmarchicus* prosome length increased with westward station progression.

Specific ingestion relation to chl. a conc. with significant linear correlation and explained significantly by type III functional response.

Low chl. a conc. corresponds with relative high egg production rates. Explanation could be e.g. food patchiness, stress induced spawning.

Grazing model could be used to estimate simple *C. finmarchicus* water column grazing rates, from depth chl a, temperature and abundance data.
### Enzyme activities across the North Atlantic

- **Iceland Basin (Stn 126, 127, 131)**
- **Irminger Basin (Stn 134)**
- **Labrador Basin (Stn 135, 136)**

#### Enzyme activities - Methods

<table>
<thead>
<tr>
<th><strong>Enzyme activities</strong></th>
<th><strong>24 C. finmarchicus CV individuals</strong></th>
<th><strong>prosome length &amp; dry mass carbon and nitrogen content</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>30 °C</strong></td>
<td></td>
<td><strong>digestive activity</strong> (proteinase, lipases/esterases)**</td>
</tr>
<tr>
<td></td>
<td><strong>3x</strong></td>
<td><strong>metabolic activity</strong> (citrate synthase)</td>
</tr>
<tr>
<td><strong>Thermal profiles</strong></td>
<td><strong>210 C. finmarchicus CV in groups of 10</strong></td>
<td><strong>digestive activity</strong> (proteinase, lipases/esterases)**</td>
</tr>
<tr>
<td></td>
<td><strong>3x</strong></td>
<td><strong>metabolic activity</strong> (citrate synthase)</td>
</tr>
<tr>
<td><strong>Acclimation experiment</strong></td>
<td><strong>240 C. finmarchicus ♀ in groups of 10</strong></td>
<td><strong>digestive activity</strong> (proteinase, lipases/esterases)**</td>
</tr>
<tr>
<td></td>
<td><strong>4°C vs. 15°C</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>5 10 15 20 30 40 50 °C</strong></td>
<td></td>
</tr>
</tbody>
</table>
Enzyme activities across the NA

- no pattern across stations from east to west
- overall low digestive enzyme activities
- overall low metabolic enzyme activities
- no correlation to environmental conditions (ambient temperature, salinity, oxygen concentration, chlorophyll concentration)

Possible explanation:
→ *Calanus finmarchicus* (CV) was still in diapause at all stations
→ enzyme activities were not influenced by ambient conditions
Lower analysis temperature range represent higher activities in colder treatment!

→ potential for **acclimation** to different temperatures in the laboratory

→ potential for **acclimatization** to different temperatures in the field (?)
Enzyme activity of Calanus (T. Schmithüsen / AWI)

Temperature profiles

Acclimation experiment

→ potential for **acclimation** to different temperatures in the laboratory

→ potential for **acclimatization** to different temperatures in the field (?)
Trophic structure of plankton communities in the North Atlantic

Objectives
- To characterise the trophic state of size-structured plankton communities in the subpolar North Atlantic
- To compare estimates of trophic levels based on biovolume spectra to those based on stable isotope analyses

Methods
- 7 stations across the North Atlantic, vertical profiles of nets and LOPC
- Stable isotope analyses: Size-fractionated net samples analysed for δ15N and δ13C in mass-spectrophotometer. Numerical estimation of trophic levels as in Bode et al. 2007
- Biovolume spectrum analyses: Size-fractionated analyses of trophic indices as in Basedow et al. 2010
Results & Conclusions (preliminary)

- The highest trophic level within the zooplankton community was observed at the Mid Atlantic Ridge, indicating high recycling.

- The situation in the eastern and western basin was more unclear, and detailed analyses in relation to chlorophyll and nutrients are needed.

- Smaller size groups were characterised by higher trophic levels than larger size groups, pointing to a higher degree of omnivory in small zooplankton.

- Trophic indices estimated by biovolume spectrum theories and by stable isotopes were not comparable. Methodological uncertainties for both estimates call for more detailed comparisons and constrained assumptions.
Mesopelagic fish were collected from:

- 1 m$^2$-D-MOCNESS, 20 nets with 335 µm mesh size, towed with 2 kn, 1250 m depth
- 4.5 m$^2$-IKMT, 20 mm mesh size & 3 mm tailbag, towed with 3.5 kn, 500 m depth

Analysis:

- 1.598 fish were collected in the IKMT and MOCNESS tows
- Standard length of each fish was measured to the nearest 0.1 mm
- Measured and identified fish were frozen in a -80 °C freezer
- Lipid and stable isotope analysis will be performed at UHAM soon.
Preliminary results:

*Benthosema glaciale* and *Cyclothone* spp. occurred in great enough numbers at all stations to examine cross transect patterns of size and abundance. Both taxa had an increase in mean SL from east to west.
Preliminary results:

*B. glaciale* also had a cross transect pattern in abundance, with higher abundances in the Iceland and eastern Irminger Basins and lower abundances in the western Irminger Basin and Labrador Sea.

![Graph showing abundance patterns](image-url)
• First results show clear differences between the basins, with deep convection only in the Iceland Basin, and generally increasing abundances of plankton and micronekton from east to west in combination with higher vital rates.

• Habitats can be linked to coupled atmosphere ocean ecosystem models to enable an assessment of the future dynamics of marine ecosystems and their services.

• Further processing and statistical analysis.

• Data integration! e.g. VPR data sets: one method to make it comparable!
THANK YOU!