Dinitrogen (N_2) fixation in the oligotrophic ocean

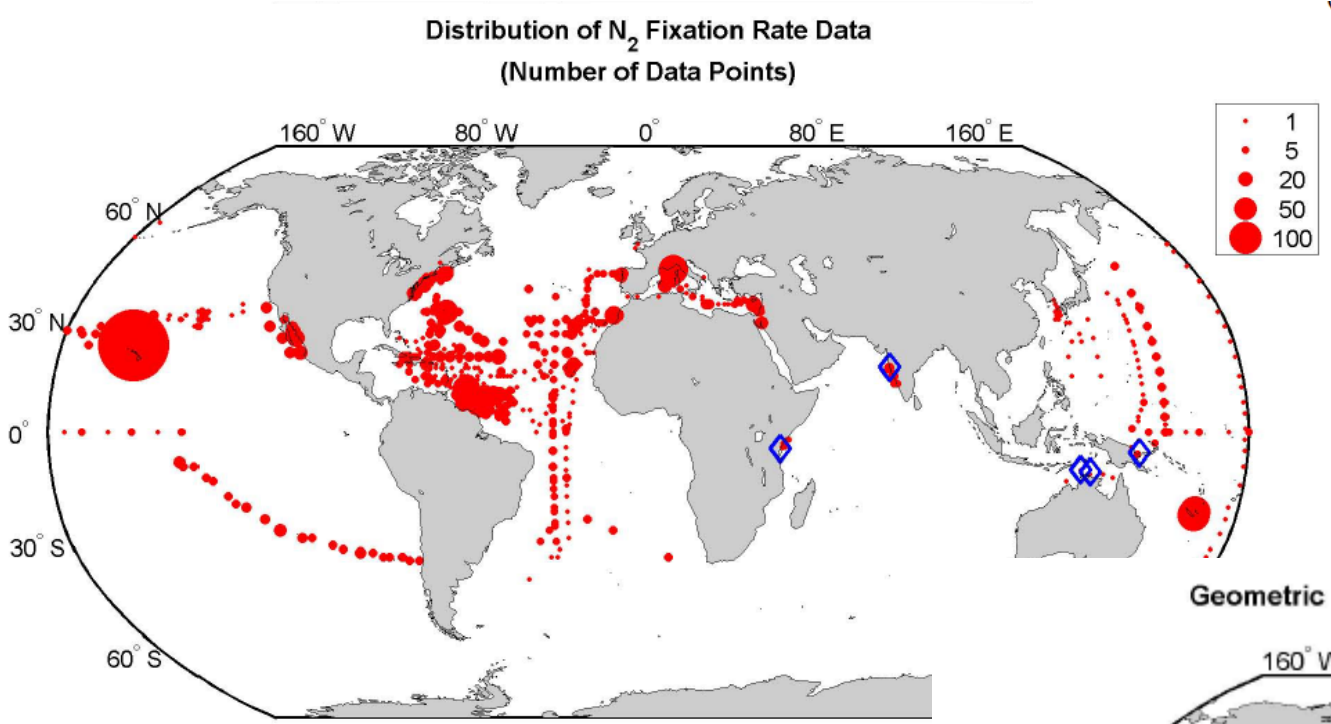
Wiebke Mohr et al.
Max Planck Institute for Marine Microbiology Bremen
Department of Biogeochemistry

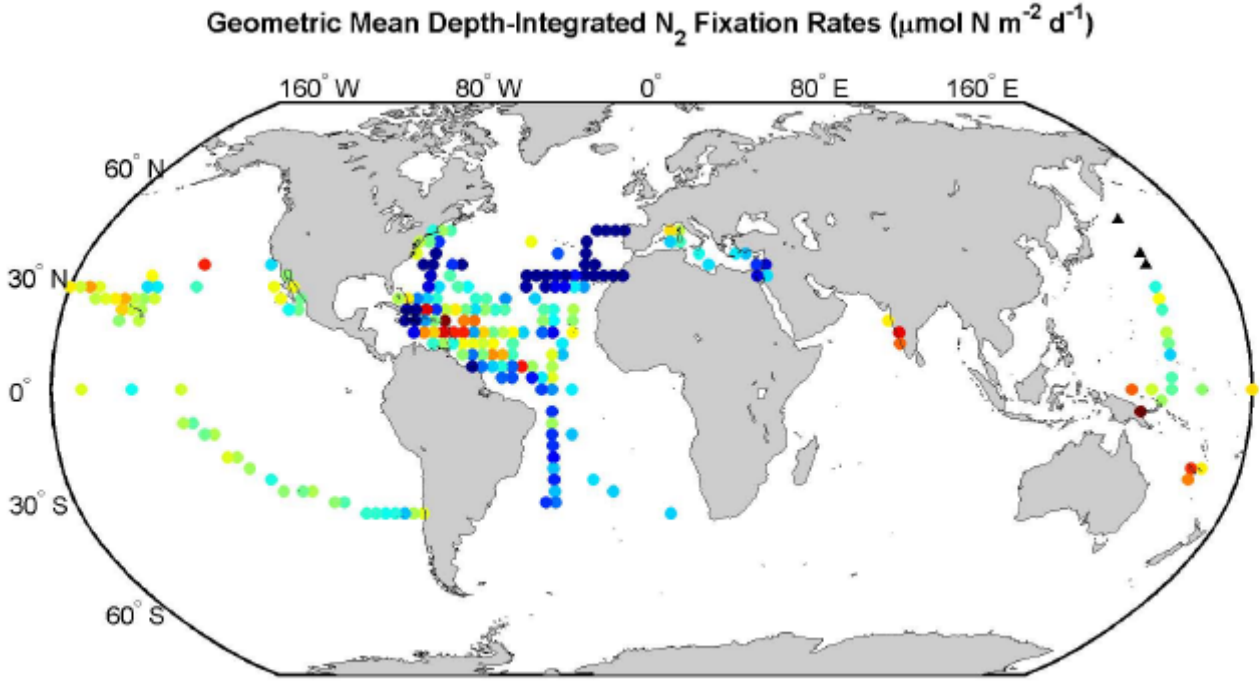
Dinitrogen fixation is the enzymatically catalyzed reduction of N_2 gas to ammonia

N_2 fixation:

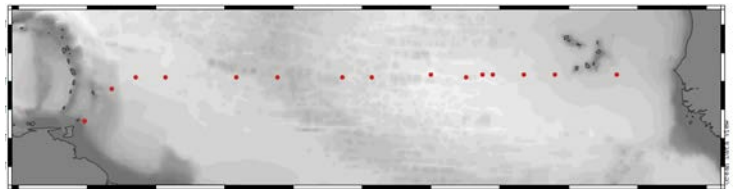
- energy-expensive
- O_2-sensitive
- Requires a lot of Fe
- (for models), it is thought to be carried out mostly by filamentous cyanobacteria
- Fertilizes the ocean with “new” nitrogen (N) and can therefore be important for export production

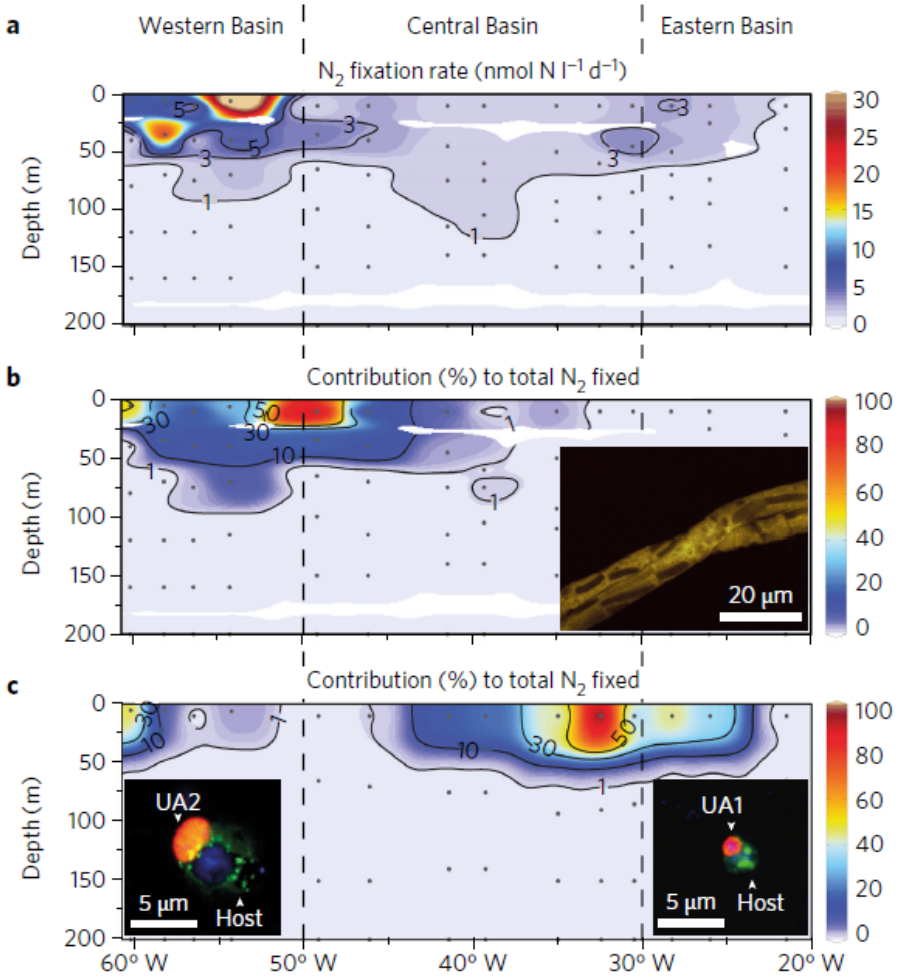
However, there are plenty of other N_2-fixing microorganisms in the ocean but we have no idea who they really are and how active they are.





Luo et al. 2012 ESSD





M96 cruise in 2013 (transect across tropical North Atlantic):

- High N_2 fixation rates in the Western Basin
- High abundances of cyanobacteria
- Two most abundant organisms only contribute about 20-40% of total N_2 fixed

→ Who else is there?

Martínez-Pérez, Mohr et al. 2016, Nature Microbiology

<u>Specifically for our cruise:</u>

What is the spatial and temporal variability?

How important is N_2 fixation for export production?

Who are the key players?

Who are the unknown diazotrophs?

(Maybe: The use of organic P since we will be in an area limited by inorganic P)

We will try to answer these with a combination of geochemical sampling, stable isotope incubations and molecular sampling.

Ocean Biology

For R/V Maria S. Merian, in our terms that is:

- Primary production (using stable isotopes)
- export production (via O_2/Ar ratios using membrane inlet mass spectrometry)
- high resolution nutrient profiles (pumpCTD)
- N_2 fixation (using stable isotopes)

Gaute Lavik

Post-Doc
(starts 09/2019)

Technician

Student

Ocean Biology

For R/V Meteor, in our terms that is:

- Primary production (using stable isotopes)
- N_2 fixation (using stable isotopes)
- (remineralization as ammonia oxidation; using stable isotopes)

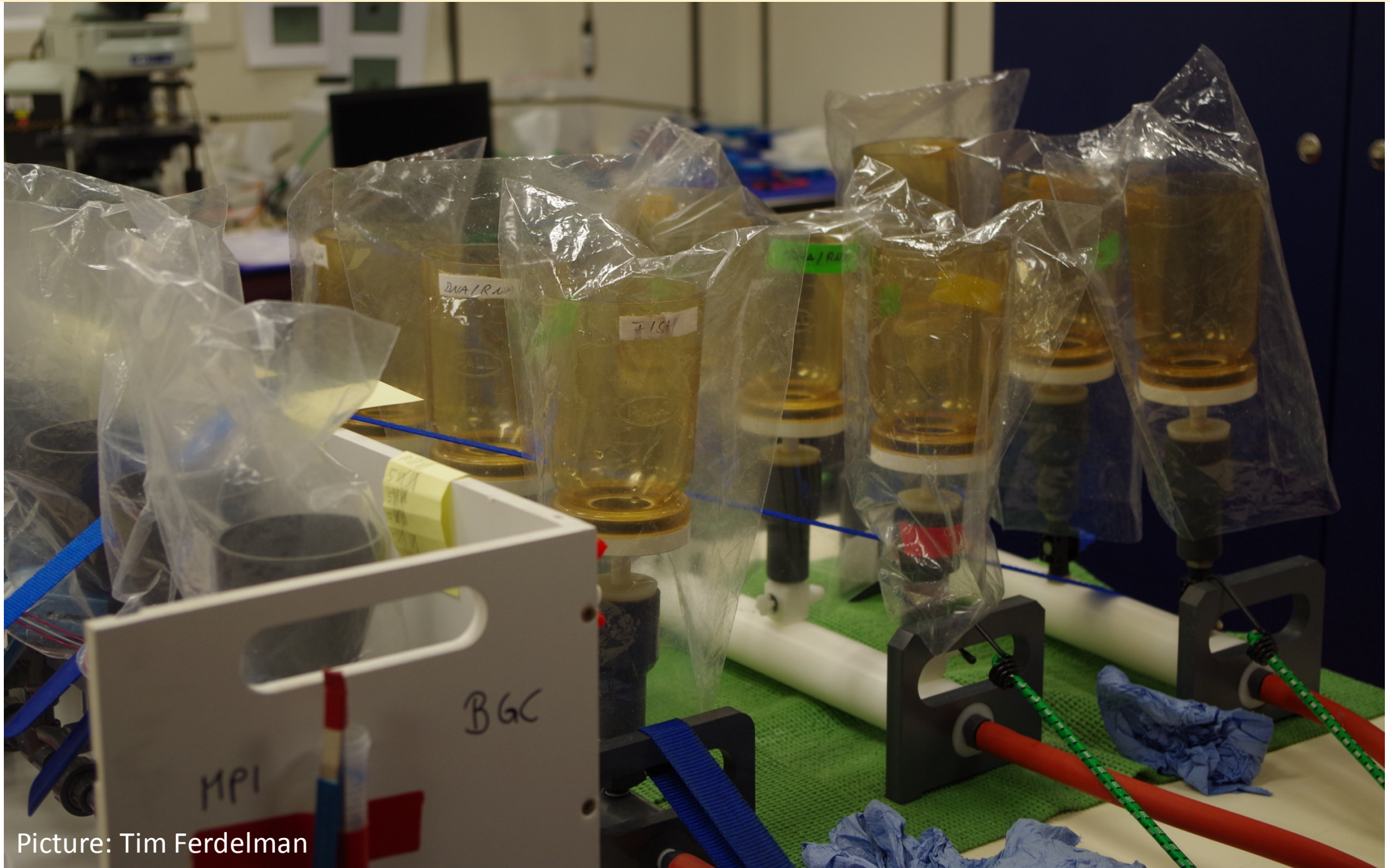
Wiebke Mohr

Miriam Philippi

Stable isotope incubations in on-deck incubators (two on each Merian and Meteor)

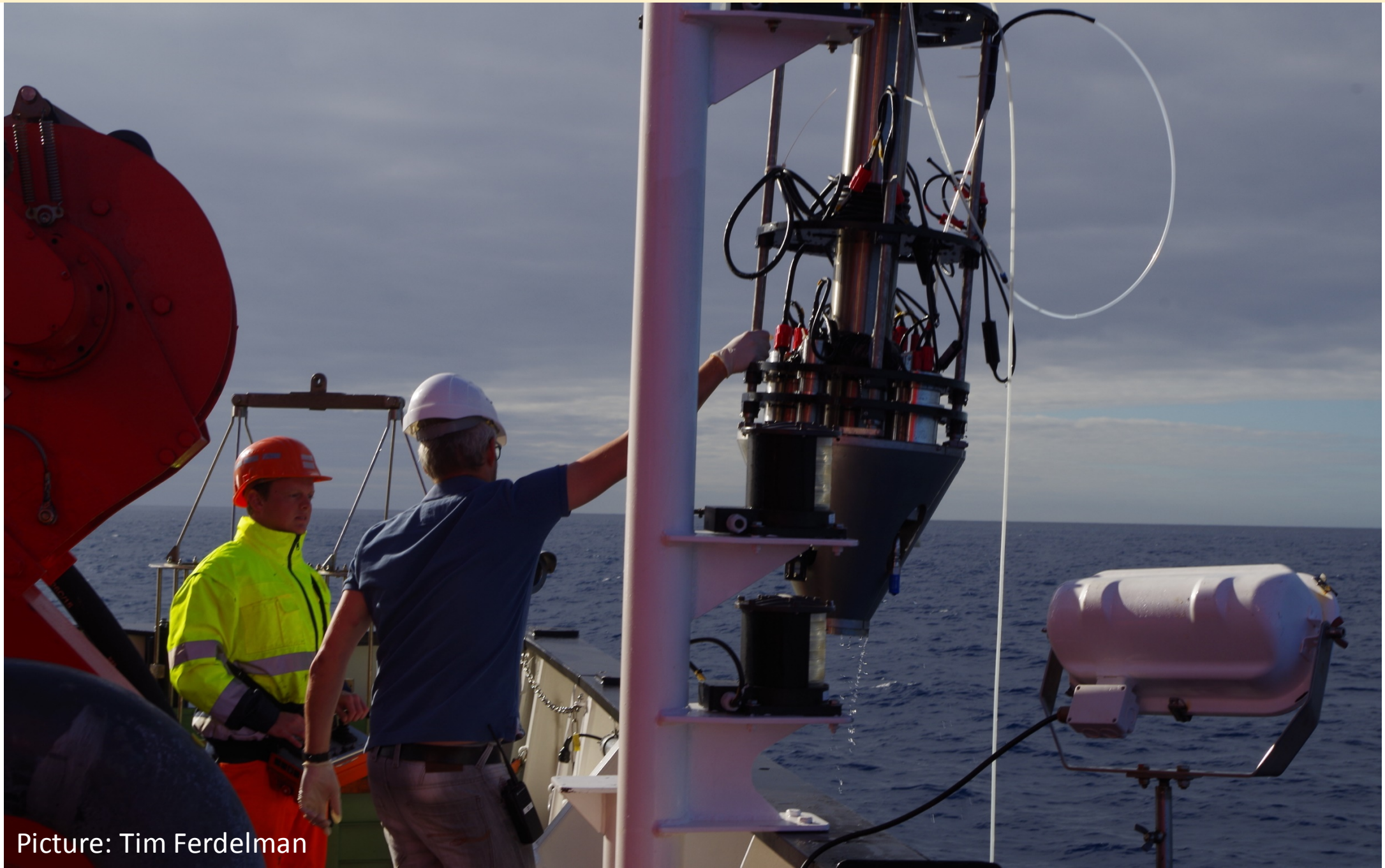
Picture: Wiebke Mohr

Lots and lots of filtrations → lab space on both Merian and Meteor

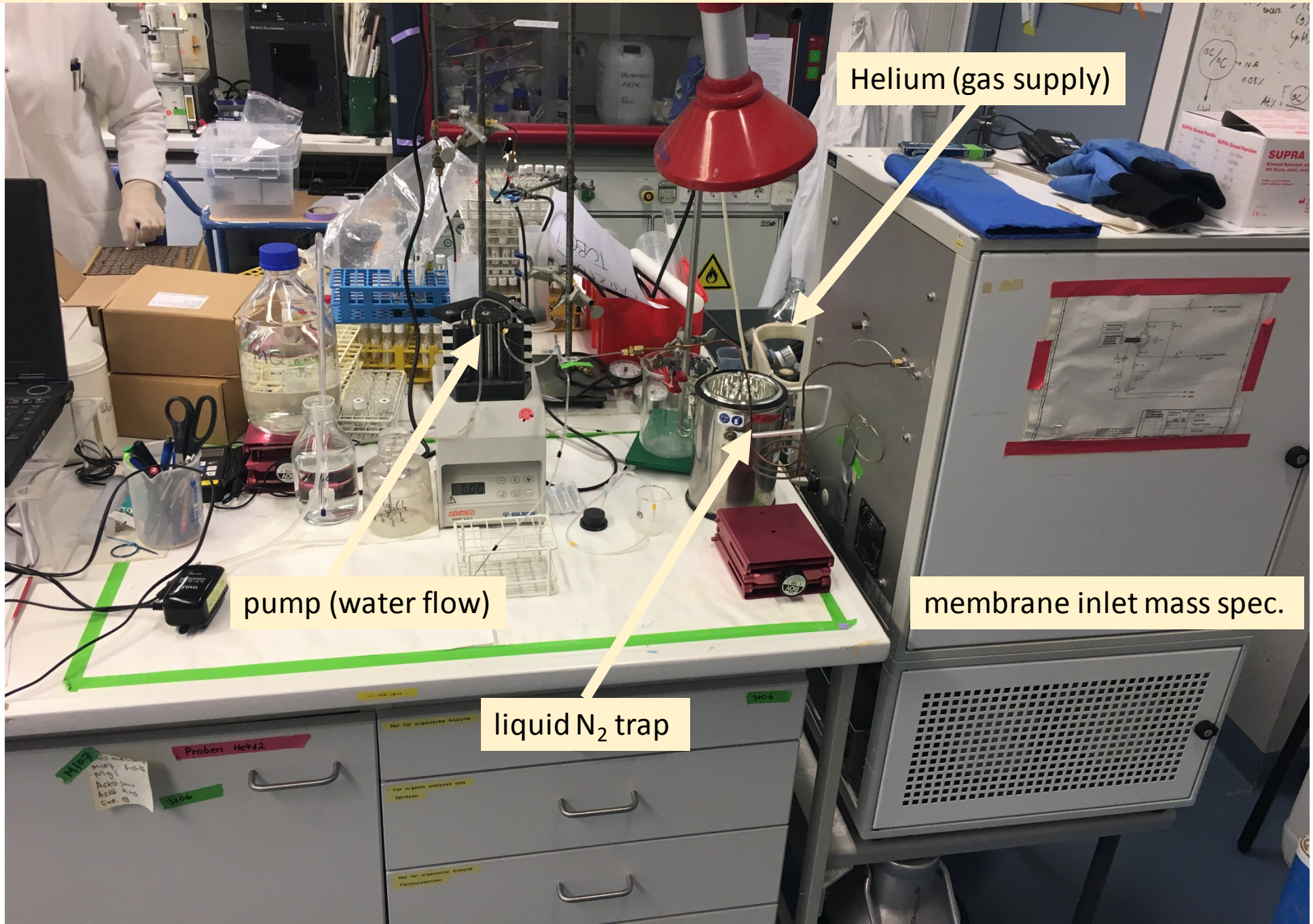


Picture: Tim Ferdelman

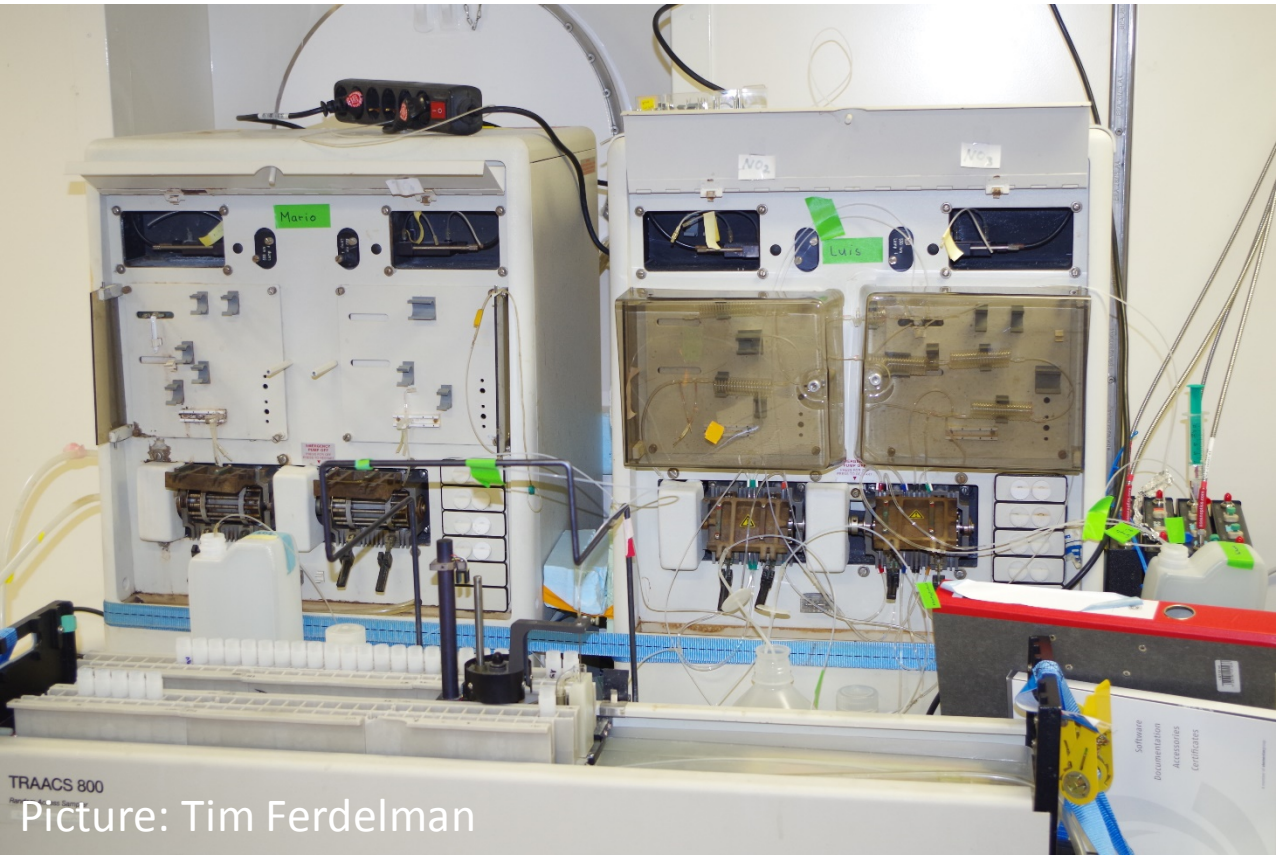
Deployment of PumpCTD system (picture from SO245 cruise)



Export production via O_2/Ar ratios (membrane inlet mass spec.) (Merian only)



nutrient autoanalyzer (Merian only)
(nitrite/nitrate)
(phosphate with long-capillary system)
(ammonium is done manually)



Picture: Tim Ferdelman

R/V Maria S. Merian

Laboratory space:
- 2 laboratories / laboratory spaces (1 for wet chemistry, 1 for stable isotopes and filtrations)
- 1 space to set-up underway and pumpCTD sampling (similar to GeoLab space on Meteor?)

Deck space:
- two incubators
    - should be in the sun all day (e.g. **NOT** next to containers)
    - flow-through seawater supply
    - from previous experience: the back of the deck seems ideal (e.g. when ship turns this space is usually still sunny)

R/V Meteor

Laboratory space:
- 1 laboratory / laboratory spaces (for stable isotopes and filtrations)

Deck space:
- two incubators
    - should be in the sun all day (e.g. **NOT** next to containers)
    - flow-through seawater supply
    - from previous experience: the back of the deck seems ideal (e.g. when ship turns this space is usually still sunny)


Picture: Tomas Wilkop

R/V Maria S. Merian

Access to:
- liquid N2
- Freezer (both -80°C and -20 °C)
- drying oven (+60 °C)
- fridge or cool room (+4°C) for temporary storage
- fume hood
- nanopure water / milliQ
- bench space with sink access

Sampling:
- from CTD
- from pumpCTD
  - (winch and (possibly) wire needed but need to confirm)
- from underway system (for O_2/Ar)
  - access to underway water system

R/V Meteor

Access to:
- Freezer (both -80°C and -20 °C)
- drying oven (+60 °C)
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- fume hood
- nanopure water / milliQ
- bench space with sink access

Sampling:
- from CTD

Shipping equipment/samples

for Merian (to and from Barbados):

- 1 container including dangerous goods (LQ normally)
- currently no air-freight planned (might change based on equipment use on other cruises and field trips)
- shipping samples from Barbados to Bremen
    - via World Courier (dry ice usually)

Shipping equipment/samples

for Meteor (to and from Barbados):

- 4 pallets (Euro-size) of space (combine with Kiel and/or HH?) including dangerous goods (LQ usually)
- currently no air-freight planned (might change based on equipment use on other cruises and field trips)
- shipping samples from Barbados to Bremen
    - via World Courier (dry ice usually)

Measured parameters, resolution, data availability etc.

- Stable isotope incubations: Samples are shipped back to Bremen and analyzed in home laboratory (mostly measured within about 1 year)
  - temporal resolution: depends on timing of stations but usually no more than 1 station per day or every 2 days
  - vertical resolution: depends on depths sampled; up to 4 depths can be handled with the no. of berths and the planned work load

- Export production (O2/Ar): raw data is near real-time, but analysis, calibration, and quality control are done back in Bremen
  - temporal resolution: near continuous if run from underway system and surface waters or in correlation to nutrients from pumpCTD → depends on no. of stations
  - vertical resolution: only if run together with pumpCTD

- nutrient measurements: measurements and analysis usually on board, quality control etc. back in Bremen (unless values are out of range and samples have to be re-analyzed back in Bremen)
  - from CTD: variable resolution, depends on station numbers
  - from pumpCTD: from main stations (out of eddy, eddy edge, in eddy?), vertical resolution is about 1-2 m (depends on ship movement, pump speed and sampling scheme)