Mini-Proposal SFB754 (Projects: A3 (Manuela Köllner) and B8 (Rainer Kiko, Helena Hauss))

Tracer loss via sinking marine particles in the tropical North Atlantic OMZ

Abstract: The goal of this project is to detect if artificial tracer (SF_5CF_3) is lost in significant amounts from the target density via sinking particles in the water column during the Oxygen Supply Tracer Release Experiment (OSTRE) conducted by sub-project A3. Tracer Release Experiments (TREs) are conducted to estimate mixing rates from the vertical and lateral spreading. The tracer is injected at a defined density and location and its distribution is mapped after several months. **An uptake of tracer at or nearby the target density and a later release at much greater density by sinking particles can cause a loss of tracer** in the sampled depth/density range and thus, **result in an error of estimated mixing rates**. We will conduct tank experiments to establish the uptake and release kinetics of SF_5CF_3 in marine particles. Combining these results with the estimated particle flux-rates for the investigation area derived from Underwater Vision Profiler (UVP) data from the cruises MSM23, M97, and M105, will enable us to quantify the tracer loss. Quantification of the loss of tracer through sinking particles will reduce the uncertainties/error-bars of the Tracer Release Experiment.

Scientific Background:

Sub-project A3 wants to quantify and better understand the supply of oxygen to the North Atlantic Oxygen Minimum Zone (OMZ). Therefore the Guinea Upwelling Tracer Release Experiment (GUTRE, 2008-2010) and the Oxygen Supply Tracer Release Experiment (OSTRE) were conducted to quantify diapycnal and lateral mixing rates. During OSTRE I the tracer SF_5CF_3 has been injected in December 2012 within the core of the North Atlantic OMZ at the density level of 27.03 kg/m³ (corresponding to an average depth of 400 m). In May/June 2013 the first tracer hunting cruise (OSTRE II) took place. SF_5CF_3 is very lipophilic and thus, has a great tendency to adhere to or dissolve in organic particles (Ho et al. 2008). For anthropogenic halogenated tracers, like CFC-12, with a low background concentration (up to 4 pmol/l) in the ocean this pathway of particulate transport has to be regarded as insignificant (Tanhua and Olsson, 2005). But the tracer SF_5CF_3 used during OSTRE and GUTRE is an anthropogenic halogenated tracer with no detectable background concentration in the ocean. Thus, the injection of several hundred Mol of the tracer in a specific area (concentrations up to 10 µmol/l) could have a different effect.

In all GUTRE tracer hunting cruises only a maximum of 70 % of the injected tracer could be found (Banyte et al. 2012, Banyte et al. 2013). The question remains if the loss of tracer is due to the sampling strategy or if part of it can be explained with a transport of tracer by sinking marine particles out of the sampled density range.

We hypothesize that a significant amount of artificial tracer is transported from the sampled depth range (100 m around the injection density of 27.03 kg/m³) by adhering to and dissolving in sinking particles.

We will test this hypothesis by

1. Measuring the uptake and release kinetics of tracer in marine particulate matter and by
2. Calculating tracer loss from the target density applying the information on uptake and release kinetics to particle distribution and estimated particle flux rates from OSTRE I (MSM23), II (M97) and III (M105) derived from UVP measurements.

During all OSTRE cruises an UVP (Picheral et al. 2010) was deployed as part of the CTD system on all CTD casts. The UVP consists of a down facing HD camera in a pressure-proof case and two red LED lights which illuminate a defined water volume. During the CTD down-cast (speed 1 m/s) the UVP takes 3-11 pictures of the illuminated field per second. For each picture the number of particles and their size is counted and stored for later data analysis. The UVP therefore yields high-resolution data on particle abundance and biovolume that can be used to estimate particle flux (Guidi et al 2009).

Project Outline/Work Plan:

1. Tracer uptake and release kinetics
   We will conduct different tank experiments with marine snow to find out how much tracer adheres to marine particles. The experimental device needs to be air tight because otherwise the tracer will gas out immediately. Therefore we will use custom-build glass burettes equipped with a glass frit. The marine particles, generated in roller tanks using Baltic Seawater, will be transferred into the glass burette. Antibiotics will be added to prevent that the marine particles will be reduced by bacteria during the experiment. Thereafter the burette will be completely filled with sea water (no remaining air bubbles are allowed) and finally the tracer SF_5CF_3 will be injected. The burette will be agitated for different amounts of time (2, 6, 12 and 24 hours) to dissolve the tracer in the water and to allow the marine particles to absorb the tracer. Then the water will be pumped out through the glass frit applying a vacuum. The tracer concentration in the water will be measured by using a purge and trap system interfaced to a gas chromatograph, which has to be equipped with an electron capture detector. The difference between the injected tracer and remaining tracer will give the value of tracer uptake by marine particles. For every experimental run this will be done with 3 burettes. In addition 3 burettes without marine particles will be prepared and measured to quantify control concentrations of the tracer.
   To measure the tracer release the burettes from 24 hour experiments are filled again with tracer-free sea water and agitated for different amounts of time. Afterwards the water will be pumped out and measured again as described before. Elevated tracer concentrations in the sampled water will derive from the SF_5CF_3 - incubated marine particles. Marine particles will be recovered from the burettes and filtered onto pre-weighed GF/F filter in order to determine their mass.

   A sketch of the experimental setup (Figure 1) can be found in the Appendix.

2. Calculating the tracer loss for OSTRE
   Tracer loss due to particle export will be calculated by combining the knowledge of uptake and release kinetics from the tank experiments with the knowledge about the particle flux in the OSTRE region (especially in the tracer injection area), which will be estimated from UVP data. The UVP was attached to the CTD at every station of both OSTRE cruises and will also be deployed during the next OSTRE cruise M105.

Time schedule:

Time	**Activity**	**Details**
Oct 2013 – Feb 2014	Dimensioning of the Experiments, purchasing equipment for experiments	GCs are not available before the M105 cruise as their setup has to be changed for our concentration range -> not possible before next

		tracer hunting cruise in March/April 2014 is done.
Mar – Apr 2014	Experiments during M105	First experiments with tracer water from Niskin bottles during the tracer hunt cruise M105.
June 2014	Measurement tests	HIWI contract (full time)
July – Aug 2014	Experiment runs	HIWI contract (full time each month)
Sep – Nov 2014	Data analysis and publication	Publication title: Tracer loss via sinking marine particles during Tracer Release Experiments in the tropical North Atlantic OMZ

Funding:

- Special equipment for experimental setup and measurements in the tracer laboratory: 3000 € (Split into: Special glass burettes: 1500 €, additional material for measurements: 1500 €)
- Shaker for incubations: 3000 €
- Student Assistant for three month (full contract)

Project extension plan:

Besides transport by sinking particles, tracer could also be transported by zooplankton which migrates through, or into and out of the target density. In order to calculate these fluxes, further experiments with zooplankton (copepods and jellyfish) could be conducted. These could also be combined with experiments to test the hypothesis that zooplankton can generate an upward flux of nutrients through absorption in their tissues (e.g. of silicate from the OMZ to the surface layer, in particular relevant for jellyfish). Experimental and observational data will furthermore be made available to the SFB754 modeling community in order to allow improvements in the modeling of tracer distributions.

References:

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- Tanhua, T., K.A. Olsson, 2005, Removal and bioaccumulation of anthropogenic, halogenated transient tracers in an anoxic fjord, Marine Chemistry, Vol. 94, pages:27-41

Appendix:

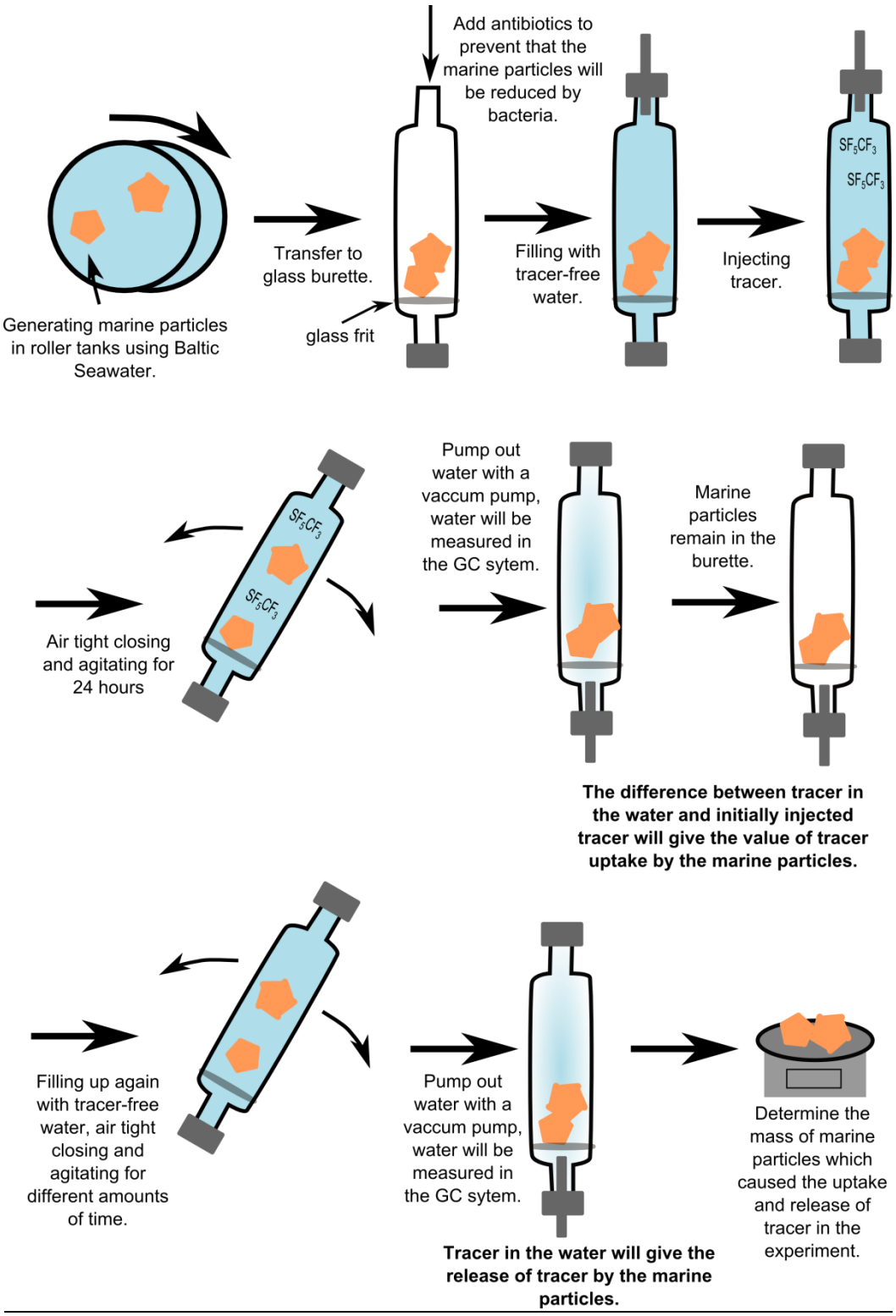

Figure 1: Sketch of the experimental setup to determine the tracer uptake and release kinetics.