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Abstract	A key aspect in mesocosm experimentation is the filling of the experimental enclosures. Not in all cases it is possible or useful to fill the enclosures with waters adjacent to the experimental site. And even for mobile mesocosm systems it is not always possible to deploy them at the desired location. To broaden the usage range of aquatic mesocosms, AQUACOSM committed to design, construct and test a large-volume water collection system which can be operated in lakes, large rivers, and marine coastal waters, be filled at variable water depths and towed for distances of several nautical miles. For this purpose a flexible wall collector capable to collect large volumes of water at variable depth and minimal disturbance has been designed and constructed at GEOMAR and was tested in various field applications. The large-volume collector is now available to be utilized by the AQUACOSM community and potential external users.

Keywords	Water collection system, large volume collector

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1. Executive summary

To broaden the usage range of the AQUACOSMS (the standardized mesocosms developed in the framework of AQUACOSM), as well as other aquatic mesocosm facilities, a large-volume water collection system was designed, constructed, tested, and further optimized by GEOMAR. The large-volume collector is intended to be operated in lakes, large rivers, and marine coastal waters, be filled at variable water depths and towed for distances of several nautical miles. For this purpose a flexible wall collector capable to collect large volumes of water at variable depth and minimal disturbance has been designed and constructed. The system has a maximum working depth of 1000 m and is capable to fill and close autonomously. It can be equipped with flexible bags of different volume. The system has now undergone various tests in the Baltic Sea and was employed in a 3-months field application off Gran Canaria. Based on the results of these tests final modifications will be made. After these modifications the large-volume collector will be available to be utilized by the AQUACOSM community and potential external users.

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2. Description of large-volume collector

2.1 Technical design

A prototype deep-water collector for the collection of water at variable depth and minimal disturbance has been designed and was constructed at GEOMAR. The flexible walls of the deep-water collector consist of fibre-reinforced food-grade polyvinyl chloride material (opaque), which is high-frequency welded into a pear-like shape with a volume of ~85 m^3 (Fig. 1A). The opening (diameter of ~25 cm) is equipped with a specifically-designed water intake device (based on a modified propeller drive) and a sealing disc as a closure mechanism for the deep water collector. Operation of both components is time-controlled (programmable), thereby allowing for remotely operated collection of water at a desired depth. A screen with 10 mm mesh size covers the opening to ensure that no large particles or organisms enter the deep-water collector. Furthermore, a weight of ~300 kg is attached to the deflated deep-water collector before deployment to submerge it in the ocean until the target depth is reached. An acoustic trigger is installed to release the weight after completion of the water intake, thereby allowing the rise of the filled deep water collector to the sea surface, only driven by the gentle buoyancy of 24 floats attached to the main frame (Fig. 1A).

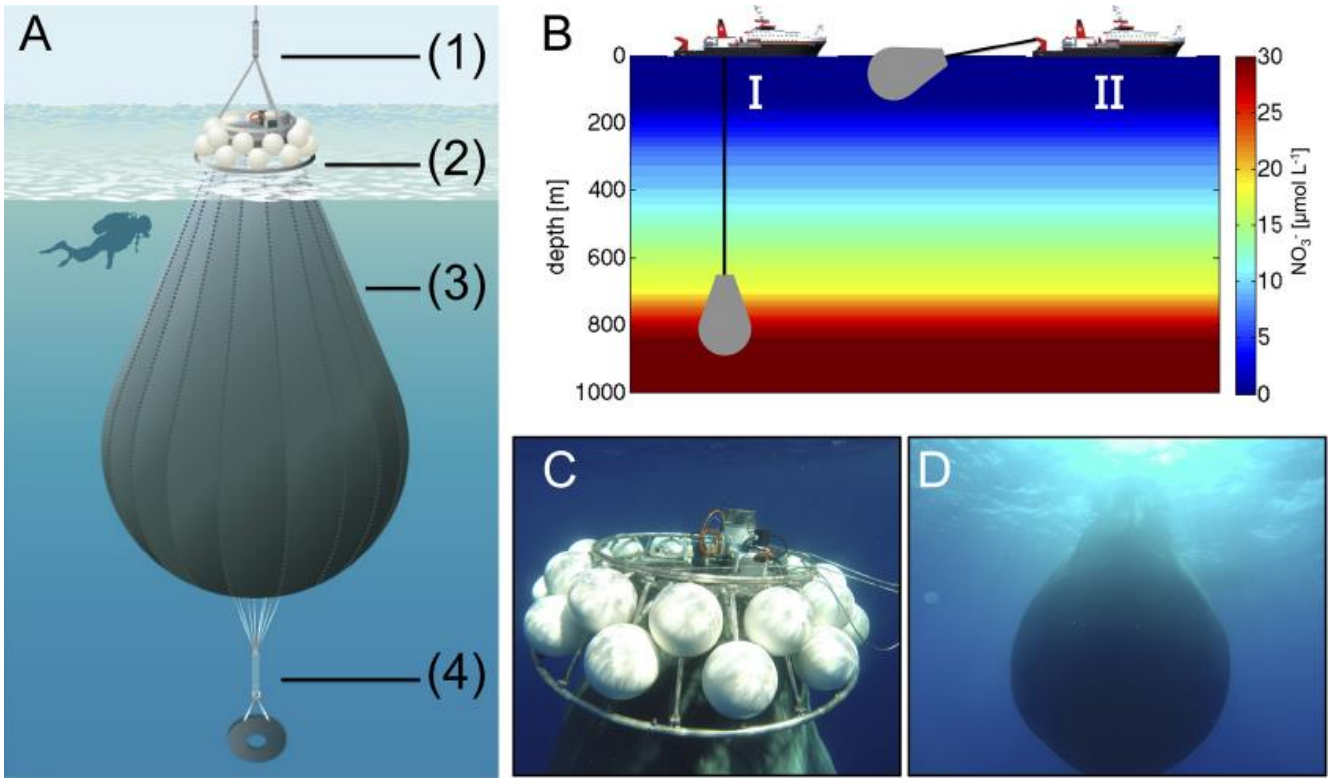

Figure 1. (A) Schematic illustration of the deep water collector, including (1) an expander for compensation of ship movement, (2) remotely-controlled filling and closing mechanism, and floatation bodies (total buoyancy ~400 kg), (3) a flexible tank welded from fibre-reinforced food-grade PVC with a volume of ~85 m^3, and (4) a weight system for submersion with acoustic release trigger. (B) Ship-operated collection of nutrient-rich deep water with the custom-designed system (I) and towing of the bag to the study site (II). (C, D) Underwater photographs of the deep-water collector after successful deployment. (Taucher et al. 2017; published independent of AQUACOSM funds).

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2.2 Field testing

After initial field testing in the western Baltic Sea and subsequent technical modifications the large-volume collector was employed in the AQUACOSM-supported KOSMOS mesocosm study conducted off Gran Canaria from October to December 2018. As the experimental design of this study requires a total volume of 160 m^3 of deep water, a second collector was built and both collectors were equipped with flexible bags of 100 m^3 volume. The collector was deployed from board of the British research vessel RRS *James Cook* at a location 5 nautical miles off the north-east coast of Gran Canaria at 27° 54.7' N, 15° 17.4' W on October 9, 2018. Deploying the large-volume collector, lowering it to 650 m water depth, filling, and closing it worked as planned. Unfortunately, the rising of the collector after the release of the bottom weight did not work properly. The collector rose to 40 m below the surface, but stopped at that depth. Our expectation that warming and thermal expansion of the enclosed cold deep water would eventually make the collector rise did not come true. The collector did not surface. A search of the collector by RRS *James Cook* and a chartered helicopter remained unsuccessful. The collector was lost. The reason why the bag did not rise to the surface remains unknown.

The deployment of the second collector was conducted two days later on October 11, 2018. This time the collector was kept at the surface and filled by a deep-water pump lowered to 340 m water depth. The filling of the bag worked properly. The filled bag was towed by RRS *James Cook* to the mesocosm deployment site in Gando Bay (27° 55.674' N, 15° 21.824' W) and was anchored next to the mesocosms for later use of the collected water. A refill of the bag was conducted as described above on November 27, without any technical problems.

Based on the experience gained during this extensive operation final technical modifications will be done before the deep-water collector will be made available to the AQUACOSM community as well as potential external users for field applications. The next scheduled operations will be in connection with two upcoming KOSMOS campaigns: one off Gran Canaria in August/September 2019 and one off Callao, Peru in February/March 2020.

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3. Dissemination activities related with the Deliverable

3.1 Research publication

The design and operation of the large-volume collector was described in the following research paper: Taucher J, Bach LT, Boxhammer T, Nauendorf A, The Gran Canaria KOSMOS Consortium, Achterberg EP, Algueró-Muñiz M, Arístegui J, Czerny J, Esposito M, Guan W, Haunost M, Horn HG, Ludwig A, Meyer J, Spisla C, Sswat M, Stange P and Riebesell U (2017) Influence of ocean acidification and deep water upwelling on oligotrophic plankton communities in the subtropical North Atlantic: Insights from an in situ mesocosm study. Front. Mar. Sci. 4:85. doi: 10.3389/fmars.2017.00085. No AQUACOSM project funds were used to support this publication.

3.2 Press release

For the first field application of the large-volume collector GEOMAR publicized a press release:

http://www.geomar.de/en/news/article/tiefenwasser-spritze-fuer-eine-lebensgemeinschaft-im-wandel/

3.3 Research blog

The field application of the large volume collector is described in a blog on the KOSMOS mesocosm campaign carried out from October to December 2018 off Gran Canaria:

https://ocean-artup.eu/blog

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4. References

[1] Taucher J, Bach LT, Boxhammer T, Nauendorf A, The Gran Canaria KOSMOS Consortium, Achterberg EP, Algueró-Muñiz M, Arístegui J, Czerny J, Esposito M, Guan W, Haunost M, Horn HG, Ludwig A, Meyer J, Spisla C, Sswat M, Stange P and Riebesell U (2017) Influence of ocean acidification and deep water upwelling on oligotrophic plankton communities in the subtropical North Atlantic: Insights from an in situ mesocosm study. Front. Mar. Sci. 4:85. doi: 10.3389/fmars.2017.00085