PROJECT REPORT

A) General Information

Proposal reference number(1)	EE-PA_202204_02
Project Acronym (ID)(2)	TRIPLE-VTests
Title of the project(3)	EMSO-MARUM_Physical_Access
Host Research Infrastructure(4)	EMSO-OBSEA, UPC-SARTI, Vilanova i la Geltru
Starting date - End date(5)	06.02.2023 – 19.02.2023
Name of Principal Investigator(6) **Home Laboratory** **E-mail address** **Telephone**	Dr. Christoph Waldmann University of Bremen/MARUM Leobener Str 8 28359 Bremen/Germany waldmann@uni-bremen.de +4917624049077
Additional users(7)	Sebastian Meckel and Axel Pirek, both from MARUM Maximilian Nitsch, RWTH-IRT, Aachen, Germany

B) Project objectives (max. 250 words (8)

The objectives were:

- Develop a strategy on how to permanently monitor the hydrodynamic behavior of a miniaturized underwater vehicle.
- Evaluate the performance of a miniaturized Ultra-Short Baseline System (USBL)
- Evaluate the performance of a Doppler-Velocity Log (DVL)
- Investigate the variability of physical ocean parameters close to the OBSEA node
- Check the performance of the high-level AI concept of the miniaturized underwater vehicle.

Why is this project innovative?

- The project will provide new insight regarding to the prediction of the hydrodynamic behavior making using of Deep Learning Neural Networks to enable long-term autonomy of autonomous underwater vehicles.
- USBL systems with a similar anticipated size has not been investigated up to now. The tests will provide reliable performance data regarding to ranges and loss of

C) Main achievements and difficulties encountered (max. 250 words)[9]

The main achievements encountered:
The opportunities that OBSEA offered for our experiments were exceptional and I can't think of any more suited infrastructure within Europe. By using the OBSEA buoy as a reference position it was possible to keep close track in real-time of the deployed navigation/
localization devices either on the AUV or as deployed from board a zodiac. With that configuration the reliability and accuracy of the localization system, the USBL and a miniaturized DVL, had been carefully evaluated. Due to the stable weather conditions during the time of our experiments it was possible to precisely map physical parameters in the water column that displayed characteristic features.
The main difficulties encountered:
The control system of our AUV system had been faulty and although a careful analysis of the possible causes was carried out together with the manufacturer of the vehicle the issue could not be solved. Accordingly, the planned tests could not been carried out to an extent that was planned for. Therefore, additional tests will be conducted later this year at OBSEA although outside of the EMSO TNA action.

D) Dissemination of the results[10]

A press release about the TNA action had been published on the EMSO, the UPC-SARTI, and the MARUM webpage (https://www.marum.de/en/Discover/Efficiently-combining-mobile-and-stationary-observation-platforms.html). The collected scientific and technical results will be published on this year's IEEE OCEANS conference in late fall.
MARUM together with UPC-SARTI could also offer to give a presentation at one of the EMSO workshops that address the evaluation of observing methods.

E) Use of the Infrastructure/Installation[11]

	In situ	By remote
Nr. of Users involved	4 Persons	0
Access units (days/months/etc)	5 days	6 days
In situ stay day / Remote Access duration	One Week	none

F) User project scientific field

Main field[12]	Earth Sciences & Environment
Scientific description[13]	Marine Science/Oceanography

H) Technical and Scientific preliminary Outcomes (max. 2 pages)(14)

The task that had been worked on during the EMSO TNA activity at OBSEA is part of a national funded project called TRIPLE-nanoAUV (TRIPLE). The aim of the TRIPLE project line is to develop a concept for an exploration system consisting of an ice melting probe together with a miniaturized AUV and an astro-biological lab that shall explore the oceans of Icy Moons in our solar system.

The experiments that were carried out at the EMSO node OBSEA served to evaluate the use of miniaturized autonomous underwater vehicles for exploring the water column properties in shallow depths, i.e., close to the surface. From a technical standpoint there is a challenge to precisely measure the position of the underwater vehicle to ensure the correct assignment of the measured variables to the related measuring spot as USBL systems that are typically used show data gaps and inaccuracies under slant range conditions. In this particular case another challenge came into the picture as the used AUV had his USBL transponder integrated into the payload nose section that may lead to situations where the corresponding fixed USBL transducer lies in the acoustic shadow of that transponder. To receive an early notice of when this issue become serious for a reliable operation of the vehicle tests under different geometric conditions had been conducted. A first glance on the type of results that were achieved are displayed in figure 1.

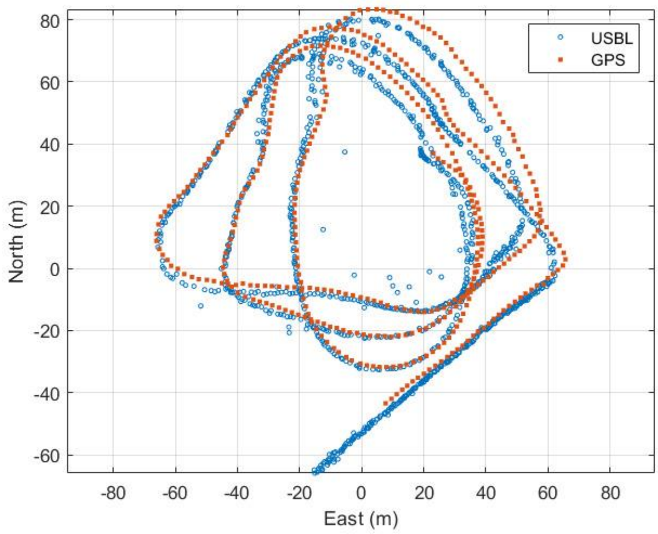

Figure 1: Comparison of USBL positions with GPS positions during an experimental set-up using a zodiac.

In that case shown in figure a drifting buoy had been used which proved to be advantageous compared to using the OBSEA buoy as with the chosen mechanical configuration in the latter case shadowing effects and depth of the reference USBL that were chosen too large had been issues.

The miniaturized AUV, the so called Micro AUV ecoSUB (https://www.ecosub.uk/ecosubu5---500-m-rated-micro-auv.html) was procured by MARUM as a test platform for evaluating additional scientific and navigation sensors. For the purpose of the field experiments the nose section of the ecoSUB had been replaced by a payload section that had been designed and built by MARUM. The sensors and the software had been developed by RWTH together with the support of MARUM and with the field tests at OBSEA the functions and the reliability of those additional sensor components had been tested.

The first preliminary results of those tests are shown in figure 2.

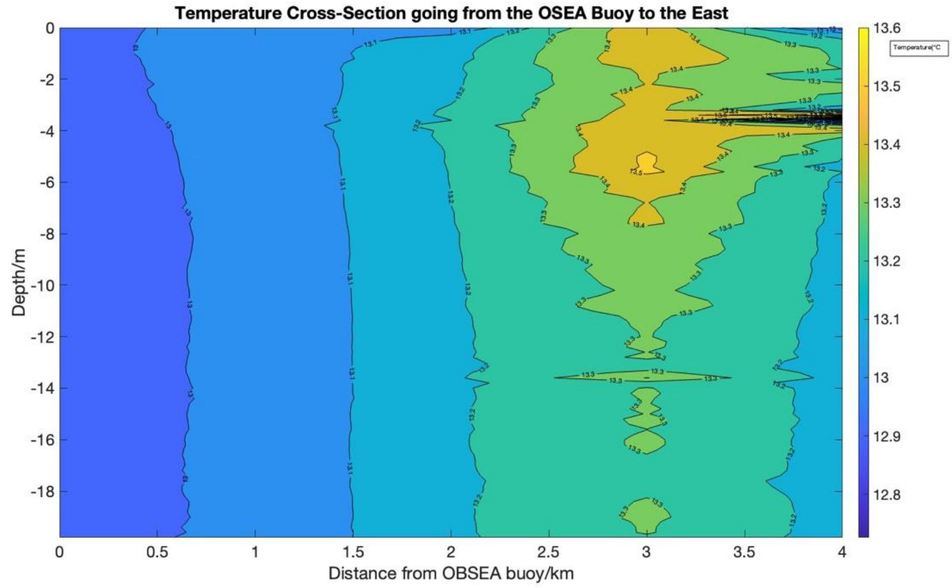

Figure 2: Temperature cross-section along an easterly path starting from the OBSEA buoy going east for 4 km

Due to the stable weather conditions no wind induced mixing occurred. Instead advected water masses deliver a structured pattern in temperature in the region around the OBSEA buoy.

Due to the issue with the control software of the ecoSUB vehicle a field trial was carried out where the vehicle was towed behind the RIB-boat of UPC-SARTI. The gliding surfaces used for this and developed for TRIPLE-nanoAUV supported the diving and proved a stable hydrodynamic behavior on the towed AUV at different towing speeds. In figure 3 the depth data during that trial is shown.

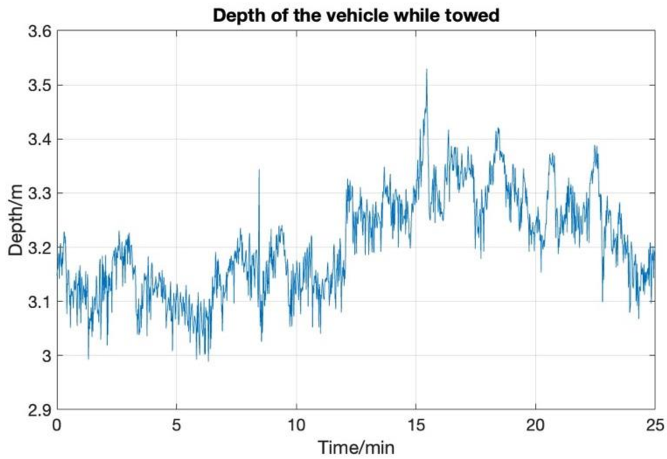

Figure 3:Depth variation of the underwater vehicle during towing

Due to the stable motion behavior of the vehicle a detailed analysis of the attitude and heading sensors as part of the inertial measuring units can be achieved. Also, additional magnetometers had been integrated that will support the localization and navigation of the vehicle.

All collected sensor data will be made available through the OBSEA and the PANGAEA data archive.