

# Mapping Technologies and Monitoring Techniques in Coral Reef Environments

*II Edition*

## REPORT

13-21 March 2023

MaRHE Center, Magoodhoo, Faafu Atoll (Republic of the Maldives)

Sponsored by:



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luca.fallati@unimib.it



# FOREWORD



# Foreword

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## Why this workshop?

Coral reefs are a complex and productive ecosystem that encompasses the highest biodiversity of any marine ecosystem. They are unique as they depend on a strong interaction between geomorphic and ecological processes.

Investigating the formation and morphological change of coral reefs and reef-associated landforms contributes to a deeper understanding of a number of geomorphological, environmental and ecological issues, such as sediment and nutrient transport processes, larval dispersion mechanisms, estimation of their carrying capacity as habitat, etc.

Moreover, it is crucial to improve coral reef conservation with a view of changing environmental conditions resulting from an increased stress by both anthropogenic and climate changes. To date, we have lost most of the global coral reef systems worldwide due to several impacts, such as overfishing, coastal development, sedimentation, marine-based pollution (e.g. plastic pollution).

Until less than a decade ago, geomorphological mapping in coral reef environments was carried out using satellite data ground-truthed by field studies. Because of this, geomorphological mapping lacked a 3D representation at high spatial resolution. As a consequence, geomorphological and habitat mapping, together with monitoring investigations, were challenging topics. Nowadays, detailed mapping of coral reef environments is possible thanks to the use of both acoustic equipment (e.g. Multibeam Echosounder - MBES) and Uncrewed Aerial Vehicles (UAVs or drones), thus we are able to map, study and plan monitoring actions to be carried out to preserve such productive ecosystems.

**The II Edition of the Mapping Technologies and Monitoring Techniques in Coral Reef Environments** is your opportunity to gain hands-on experience on data acquisition and post-processing techniques by using different equipment, focusing on the importance of cutting-edge monitoring techniques for mapping coastal and nearshore environments.

# Foreword

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## About the workshop

During the previous edition of Mapping Technologies in Coral Reef Environments in 2019, the main goal of the practical training was to provide an overview of the most advanced technique used to collect elevation data in coral reef environments and to integrate multi-scale elevation datasets to obtain seamless Digital Terrain Models (DTMs).

The II Edition of this practical training was called Mapping Technologies and Monitoring Techniques in Coral Reef Environments. It aimed to provide advanced knowledge on planning and carrying out multi-scale and multi-sensor monitoring activities in nearshore environments. The workshop was supported by the National Biodiversity Future Center (<https://www.nbfc.it/>).

This course entailed an overview of the most advanced techniques used to collect remote sensing data in coral reef environments (UAV, Underwater Photogrammetry and MBES). We presented post-processing procedures for both MBES data (Bathymetry and Backscatter) and UAV imagery (Structure for Motion - SfM) and data interpretation.

Lessons were held at the Marine Research and High Education Center (MaRHE Center) of Milano-Bicocca University in Magoodhoo Island, Faafu Atoll, which is about three hours by speedboat from Malé airport.

Field activities were carried out either onboard a traditional Dhoni (wooden sailing vessel) or in snorkelling.

Practical activities included the use of dedicated software for processing collected data and performing their integration and interpretation.

# ORGANIZING TEAM



# Organizing Team

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## The Team

The workshop was coordinated by Dr. Luca Fallati, Melissa Anne Schiele, Andrea Giulia Varzi, Nick Wagner with Ocean Unmanned NGO, Fernando Castro Cardoso and Dr. Beatrice Ruggieri. **Thanks to the multidisciplinary entailed in the organizing team, it was possible to enrich the training workshop by presenting the Mapping and Monitoring topics from different perspectives.**

**Dr. Luca Fallati** is a Researcher in the Department of Earth and Environmental Sciences (DISAT) at the University of Milano-Bicocca. His research is mainly centered on marine geomorphology and habitat mapping in coastal and submarine environments, with a particular focus on innovative remote sensing technologies for multiscale approach in changing environments, together with underwater photogrammetry and reconstruction of 3D models for immersive Virtual Reality (VR) scenarios.

**Melissa Anne Schiele** is a senior international project manager and conservation technologist who is working towards a PhD in Engineering at Loughborough University and the Zoological Society of London. Her research focuses on developing fixed-wing drones and creating methods and protocols for their use in remote locations, for wildlife monitoring, plastics detection and illegal fishing surveillance. She is also developing augmented technology acceptance models to understand long-term use of systems in the hands of end-users in developing nations.

**Andrea Giulia Varzi** is a PhD candidate in the DISAT at the University of Milano-Bicocca. Her scientific interests are towards geomorphological and habitat mapping, together with habitat and restoration suitability models. Her research is focused on the “white ribbon” area, the land-sea continuum, to define a reference workflow to integrate high-resolution multi-scale and multi-source geospatial datasets for creating seamless models to bridge the gap.

# Organizing Team

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## The Team

**Oceans Unmanned** is an NGO created to facilitate the use and harness the power of unmanned technology to foster marine research and conservation. Founded in 2016, Oceans Unmanned (OU) is dedicated to protecting our ocean and coastal environments and inspiring an optimistic mindset that can address long standing challenges through the use of cutting-edge technology. OU provides operational and research support to scientists and resource managers worldwide to address a wide variety of environmental issues including: climate change, sea level rise, marine debris, wildlife surveys, habitat mapping and more.

**Nick Wagner** is a conservation technologist, primarily working with Unoccupied Aerial Systems (UAS), to leverage the aerial perspective for better insights and greater impacts. Based in Portland, Oregon, Nick's work encompasses local issues of sustainable forestry and habitat improvements for endangered salmon populations, as well as work further afield contributing to ongoing AI-based research on marine debris and clean-up efforts at the Great Pacific Garbage Patch.

**Fernando Castro Cardoso** is a graduate student at the Federal University of Rio de Janeiro with experience in marginal coral reef environments' ecology and monitoring. He is currently assessing how coral colonies respond to severe thermal anomalies and how they adopt different growth strategies depending on light environments. To achieve this, he is using state-of-the-art photogrammetric techniques with underwater photo surveys in Abrolhos, Northeastern Brazil. His background as a SCUBA diving instructor and underwater photographer pushes him even further in the desire to explore, study and monitor reef systems all around the world.

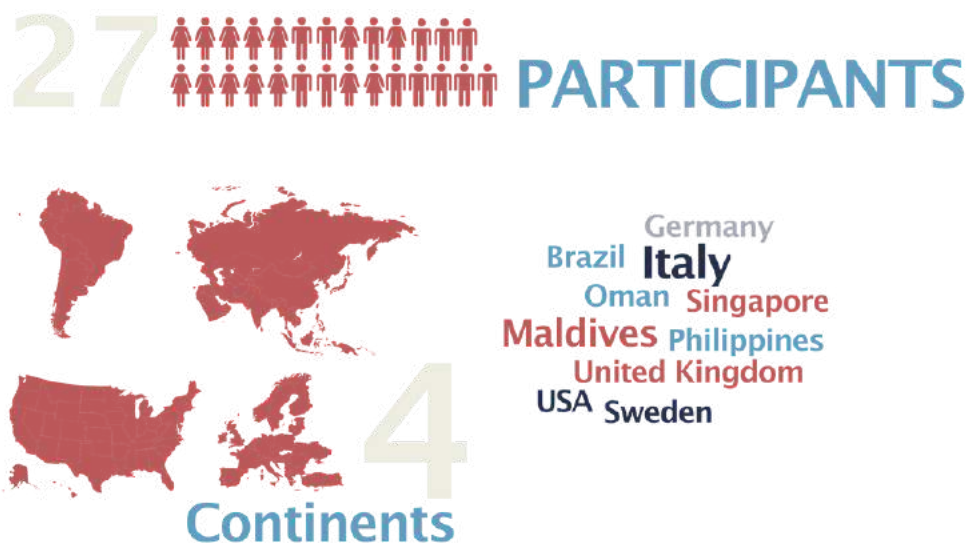
**Beatrice Ruggieri**, PhD, Geographer, is a post-doc in the "Riccardo Massa" Department of Human Sciences for Education at the University of Milano-Bicocca. She is currently working in collaboration with the NBFC - National Biodiversity Future Centre on a project entitled "For the Sustainable Use of Biodiversity in the Indian Ocean. Protocols and Guidelines for SIDS", with a focus on land reclamation processes in the Maldives. Her research focuses on developing guidelines for biodiversity conservation in small island states



# PARTICIPANTS



# Participants



**ITALY:** Giulia Airoidi, Ruxandra Iulia Mantea, Giorgia Pizzaballa, Sara Scroglieri, Martina Sirtori, Federica Di Lauro, Elisa Ripamonti, Andrea Beretta, Simone Moretti, Matteo Vergani, Lorenzo Casanova, Alberto Scalzini **OMAN:** Sara Al Balushi, Al Lawati Ahmed **SWEDEN:** Li Ling **USA:** Elizabeth Perez, Erin Bowman **MALDIVES:** Fathmath Shuhaina, Mohamed Aleem Ibrahim, Aiman Mohamed, Ali Ahmed Didi, Hashim Nabeel Abdulla, Aishath Amjidha **GERMANY:** Alexandra Hanusch **UK:** Dominic Bryant **PHILIPPINES:** Darryl Anthony Valino **SINGAPORE:** Ong Jia Jie

# STRUCTURE AND CONTENTS



## Structure and Contents

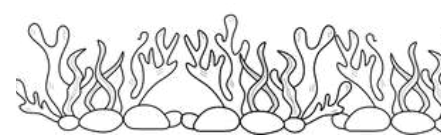


**The workshop consisted of a series of frontal lessons and field activities for a total of more than 70 hours of training.** It was coordinated by researchers with experience in the use of aerial drones and underwater instruments for coastal and seafloor mapping (bathymetric and habitat) and photogrammetry techniques.



After completion of this training course, the participants were able to:

- plan drone surveys with the ground station software (Mission Planner and UgCS and conducts the survey with different platforms (fixed wings and multirotor);
- perform the survey and georeference models with GPS ground control points;
- recognise main carbonate producers in coral reef environments;
- plan a geomorphological survey in coral reef environments;
- collect terrestrial and submarine topographic data using different technologies (UAV and MBES);
- process MBES bathymetric and backscatter with specific software (QPS Quinsy, Qimera and FMGT);
- process imagery data with Structure from Motions (SfMs) algorithms to build orthomosaics and/or 3D models (Agisoft Metashape);
- create geomorphological and habitat maps (ArcMap).



# Structure and Contents

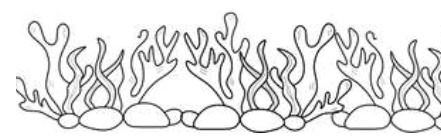
## Daily program in details

### DAY 1

- Arrival at Malé International Airport, Maldives
- Transfer by speedboat to MarHE Center, Magoodhoo Island
- Welcome to Magoodhoo island
- Dinner
- Briefing on the next day's activities

### DAY 2

- Classroom Session: Coral Reef Environments
- Classroom Session: Remote sensing data retrieval
- Laboratory Session: Group division and software installation
- Laboratory Session: Project choice
- Lunch
- Classroom Session: UAV introduction
- Field Activity: UAV equipment
- Field Activity: Snorkelling and water confidence
- Dinner
- Seminary: Melissa Schiele



# Structure and Contents

## Daily program in details



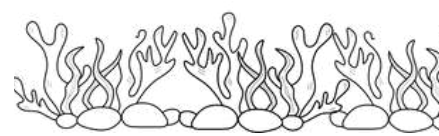
### DAY 3

- Classroom Session: How to plan a UAV survey
- Laboratory Session: Mission planner: ArduPilot Open Source ground station
- Laboratory Session: Mission planner: UgCS software
- Laboratory Session: UAV survey planning
- Lunch
- Laboratory Session: UAV survey planning
- Classroom Session: SfM software: Agisoft (Metashape)
- Field Activity: UAV data acquisition
- Dinner
- Seminary: Nick Wagner



### DAY 4

- Field Activity: UAV data acquisition
- Laboratory Session: UAV data processing
- Lunch
- Laboratory Session: UAV data processing
- Field Activity: UAV data acquisition
- Dinner
- Seminary: Angela Albi & August Paula



# Structure and Contents

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## Daily program in details



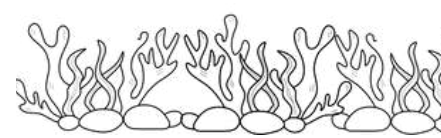
### DAY 5

- Classroom Session: Best practices for Underwater Photogrammetry
- Field Activity: Underwater photogrammetry (Byledhoo)
- Laboratory Session: Underwater photogrammetry processing
- Lunch
- Laboratory Session: Group working time
- Field Activity: Underwater photogrammetry (Byledhoo)
- Laboratory Session: Underwater photogrammetry processing
- Laboratory Session: MBES survey planning
- Dinner
- Seminary: Fernando Castro Cardoso



### DAY 6

- Classroom Session: Acoustic survey in shallow waters (MBES)
- Field Activity: MBES data acquisition
- Lunch
- Field Activity: MBES data acquisition
- Classroom Session: MBES data processing - Qimera
- Dinner
- Seminary: Andrea Giulia Varzi & Beatrice Ruggieri



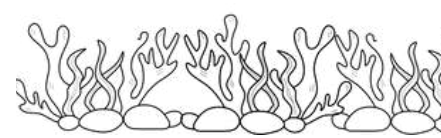
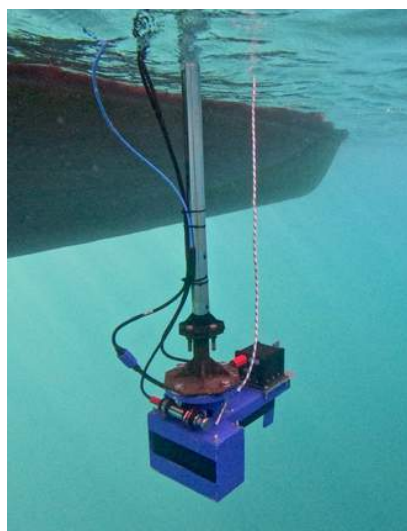
# Structure and Contents

## Daily program in details



### DAY 7

- Travel to Adangau
- Field Activity: MBES data acquisition (Adangau)
- Lunch
- Field Activity: UAV/photogrammetry data acquisition (Adangau)
- Travel to MaRHE Center
- Laboratory Session: MBES/UAV/photogrammetry data processing
- Dinner
- Briefing on the next day's activities





# Structure and Contents

## Daily program in details



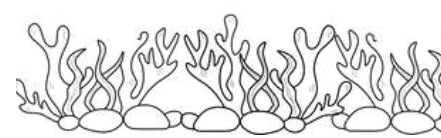
### DAY 8

- Field Activity: Snorkelling
- Laboratory Session: Group working time
- Lunch
- Laboratory Session: Group working time
- Classroom Session: Final presentations
- Free time
- Dinner
- Boduberu



### DAY 9

- Transfer by speedboat to Malé, Maldives
- Arrival at Malé International Airport, Maldives

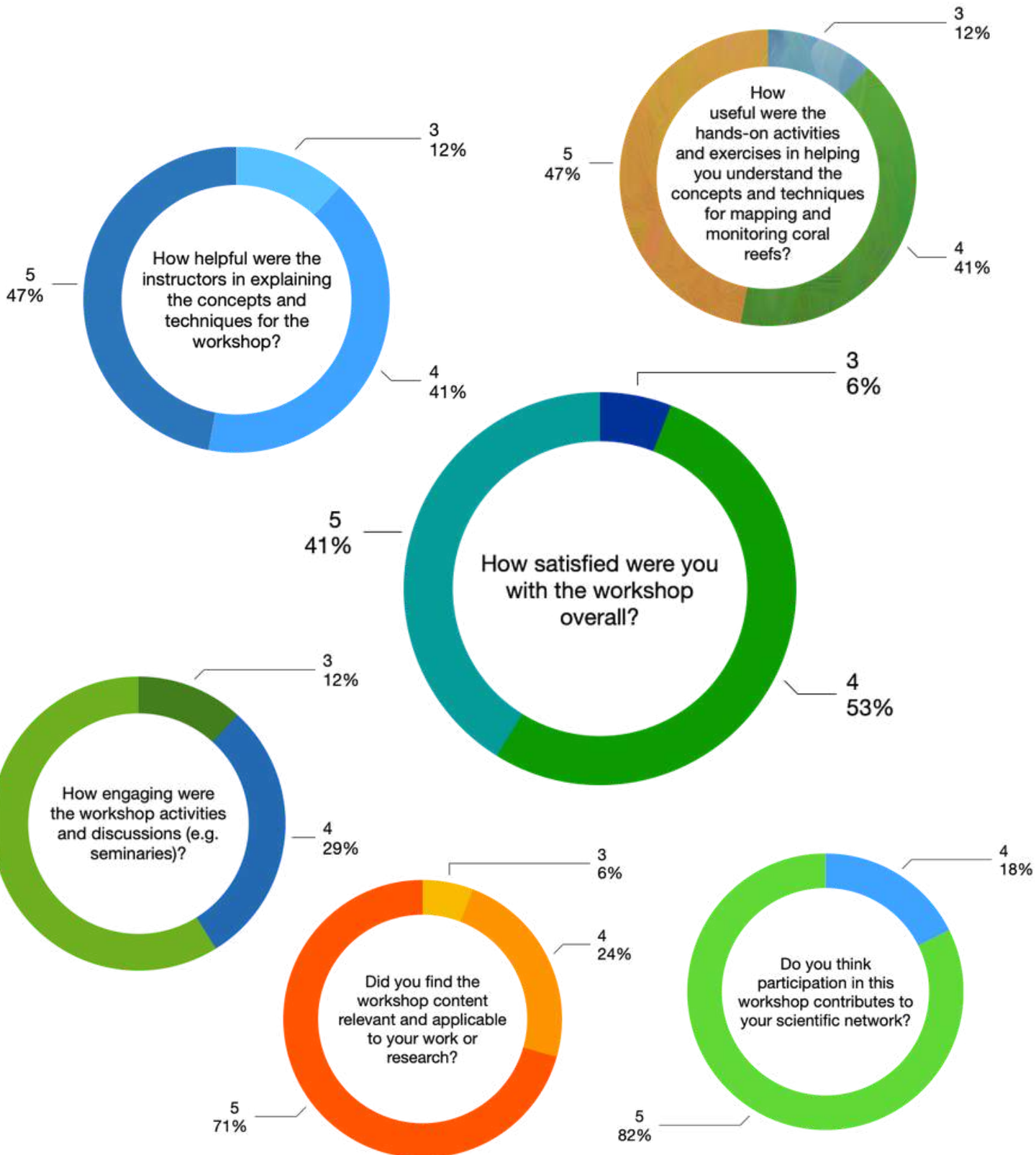


# PARTICIPANTS EVALUATION



# Participants Evaluation

Anonymous evaluation using a scale from 1 to 5 (1=poor, 5 =excellent).  
The results were derived from 20 feedback.



# WHAT PARTICIPANTS APPRECIATED THE MOST ABOUT THE TRAINING?



"The *international group* and learning from experts in their field."

"Great *atmosphere* created by instructors and staff, making it a conducive place for learning."

"Hands-on experience and data collection."



"Having all *different backgrounds and expertise* made the knowledge exchange so much more *interesting and powerful*."

"International atmosphere and wide topic/ instruments presented"

"I loved the hand-on aspects of the workshop - how we learned something and then applied it to real life in the field."





**A huge thank you to such a wonderful group!**



**Stay tuned for the next edition!**