REPORT ON POGO WORKING GROUPS

Contractor's Report

Title of Working Group

Unlocking the potential of consumer-grade drones as tools for tropical marine and coastal research relevant to the UN Ocean Decade (Workshop)

Name of Contractor

Leibniz Centre for Tropical Marine Research (ZMT)

Names of Participants: 32 (21 presenters)

Total expenditure to be reimbursed (please attach a financial report with copies of receipts): 16,373.51

1. Please provide a brief description of the activities undertaken by the working group.

1.1. Workshop sessions and presentations

From the 26-28th June 2023, the Leibniz Centre for Tropical Marine Research represented by Sonia Bejarano organised and hosted the scientific workshop *Unlocking the potential of consumer-grade drones in marine research*. The workshop took place in a hybrid format and all presentations were recorded. Key partners in this workshop included three POGO members, namely the Euro-Mediterranean Centre on Climate Change (CMCC, Italy), Institut de recherche pour le dévelopment (IRD, France), and Instituto de Investigaciones Marinas y Costeras (INVEMAR, Colombia). The workshop aimed to bring together marine scientists who use drones for their research as well as representatives from drone manufacturing or commercialisation sector, experts in the legislation of drone use (in and outside the EU), and teams that offer concrete applications of drone-derived information. A total of 25 speakers where invited between January and April 2024, 17 of whom accepted to give in-person presentations (with one last-minute cancellation) and four confirmed *on-line* participations. Presentation titles were sorted in three sessions according to scope: **Session 1** (**June 26**) *What do coastal and marine researchers use/need drones and machine learning for*? **Session 2** (**June 27**) *What is the state of the art in drone technology/capabilities and machine learning and how do these support or limit scientists aims and needs*? and **Session 3** (**June 27**) *What is the current status of the legislation regulating drone use in EU projects and in the tropics*? an agenda was prepared and broadly announced via various communication channels handled by ZMT.

The programme included one keynote presentation, 17 regular talks, and interactive working sessions to co-develop a joint perspective manuscript that could shed light on urgent knowledge gaps that could be addressed through a joint proposal (Fig. 1.). Each day included half a day for presentations (open to the public) and a 3-hour focused time window in which workshop organisers and presenters co-worked

Fig. 1. Images taken during the hybrid workshop *Unlocking the potential of consumer-grade drones in marine research* (26-28th June 2023, Bremen Germany) by Andrea Daschner (ZMT). From top left to bottom right: i) Opening slide by Sonia Bejarano, ii) Welcoming words by ZMT Scientific Director Raimund Bleischwitz, iii) Opening slide of presentation by Alessio Rovere, iv) Presentation by Gustavo Castellanos, v) co-working session to develop joint manuscript, vi) Slide from online recorded talk by Karen Joyce.

in shaping the scope of the joint manuscript, defining the potential content and subsections and preparing draft texts.

Day 1 started with welcome words by the Scientific Director of ZMT Professor Raimund Bleischwitz followed by scientific talks within Session 1. In Session 1, presentations focused on the current applications of drones, 3D photogrammetry and machine learning for marine and coastal research projects (Fig. 2).

A total of 10 presentations were delivered within Session 1 by scientists from 10 different institutions and five countries (Germany, La Reunion, Colombia, Ghana, and Italy). Presentations spanned projects using drones to study both attributes and processes of coastal ecosystems. Casella and Rovere, for

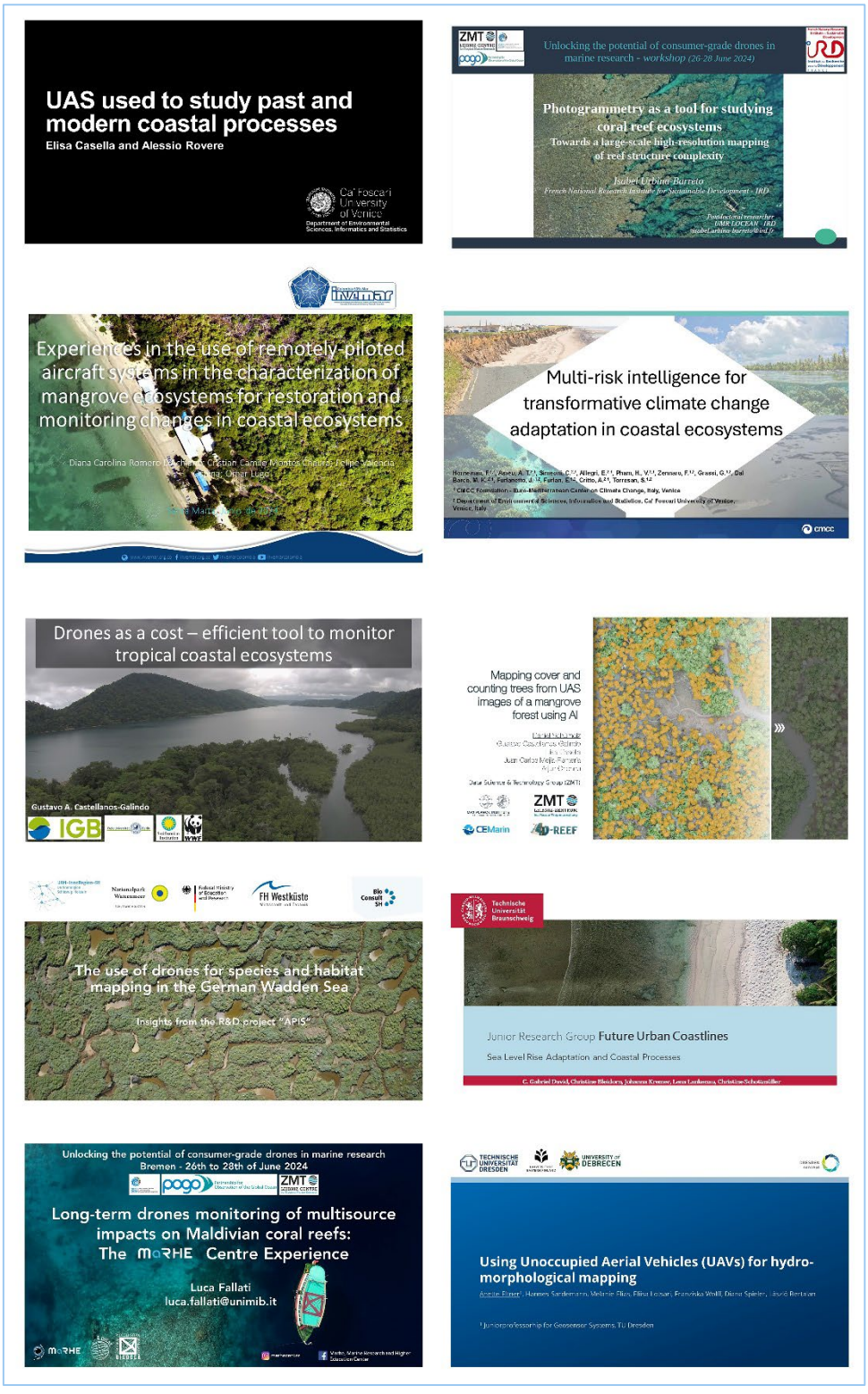

Fig. 2. Day 1. The scientific use of drones for coastal and marine science. Examples of presentations regarding the use of drones in multiple research marine and coastal projects.

instance, presented advances in the use of drones for coral reef habitat mapping, quantification of coral reef topography and rugosity, erosion of sandy beaches, and determination of canopy heights in mangrove forests. Further, presenting three case studies in the Western Indian Ocean, Urbina-Barreto

expanded on the use of drone imagery and underwater photogrammetry to map coral reefs and seaweed farms, as well as on the ongoing upscaling of drone surveys to contribute to coral reef conservation efforts. Romero shared her experiences using drones to map the spatial cover and health status of mangrove ecosystems in Colombia to aid conservation and restoration planning. Furlanetto highlighted the importance of using drones within a multi-risk approach encompassing the water network from rivers to the ocean and considering ecosystem dynamic processes along this continuum, while demonstrating the usefulness of drone data to develop small-scale cumulative impact assessments for local stakeholders. Castellanos-Galindo brought examples using drones to document the aerial exposure of coral reefs to extreme spring tides, distinguish vegetation types in mangrove forests, and provide insights into forest degradation processes while highlighting the importance of using drone derived data in combination with other remotely sensed data. Quashingah explained his work monitoring coastal dynamics using drones. David presented further details on the use of drones to map coastal morphodynamic processes that can be affected by sea level rise and presented novel insights into the digitalisation and 3D printing of reefs and the principles of additive manufacturing. Eltner provided an overview on the use of drones in fluvial surveys for topographic mapping, bathymetry reconstruction, and the measurement of flow velocity and discharge. Fallati presented drone imagery collected to monitor coral reef and seagrass extension, as well beach plastic pollution in the Maldives. He presented coral reef examples where drone data, integrated with underwater photogrammetry, capture the progression of coral reef bleaching events on both natural and restore reefs, and where photogrammetry alone is used in a citizen science project to locate the worlds' largest coral colonies. Particularly useful to this workshop, Fallati presented the recently published report on *Mapping technologies and monitoring techniques in coral reef environment*. Lastly, Schürholz expanded on the use of drones to create orthomosaics, digital terrain and elevation models, and canopy height models of mangrove forests. He presented these within an automation workflow including Deep Learning, anticipating that experimental advancements in AI promise to improve performance of predictions.

Day 2 started with the keynote presentation titled *Drone Mapping the Great Barrier Reef* by Karen Joyce. The presentation gave a thorough overview of ongoing efforts to map the Great Barrier Reef whilst quantifying the number of live corals. This is a challenging, yet highly relevant question, given that at the time of the presentation, ongoing heat waves had triggered the fourth global mass bleaching event ever recorded. Joyce presented a compelling case that out of all the remote sensing products available, live coral cover can only be clearly quantifiable in drone-generated imagery. She caveats, however, that single scientists running underwater ecological surveys or drone surveys are not able to cover the geographic extent at which global change phenomena (e.g., mass bleaching) are taking place. Drone imagery is increasingly being collected by thousands of people around the world, and this represents a huge, yet untapped Earth Observation effort. As well as undervalued, the amount of drone data collected globally is not necessarily archived in an accessible or findable manner, and not everyone has the expertise to access the useful information. This is explained as the major rationale for her efforts to make drone-imagery collection procedures, data analysis steps, and mapping routines as simple as they need to be for a 6-year old to understand and learn them and to design a global repository accessible to citizen scientists globally. She explains how her global repository hosts now >1.8M in drone images from 80 countries with 9.5K users. This effort to maximise the accessibility of drone data is paired with a special education programme for children now run in 15 countries with 21 industry partners.

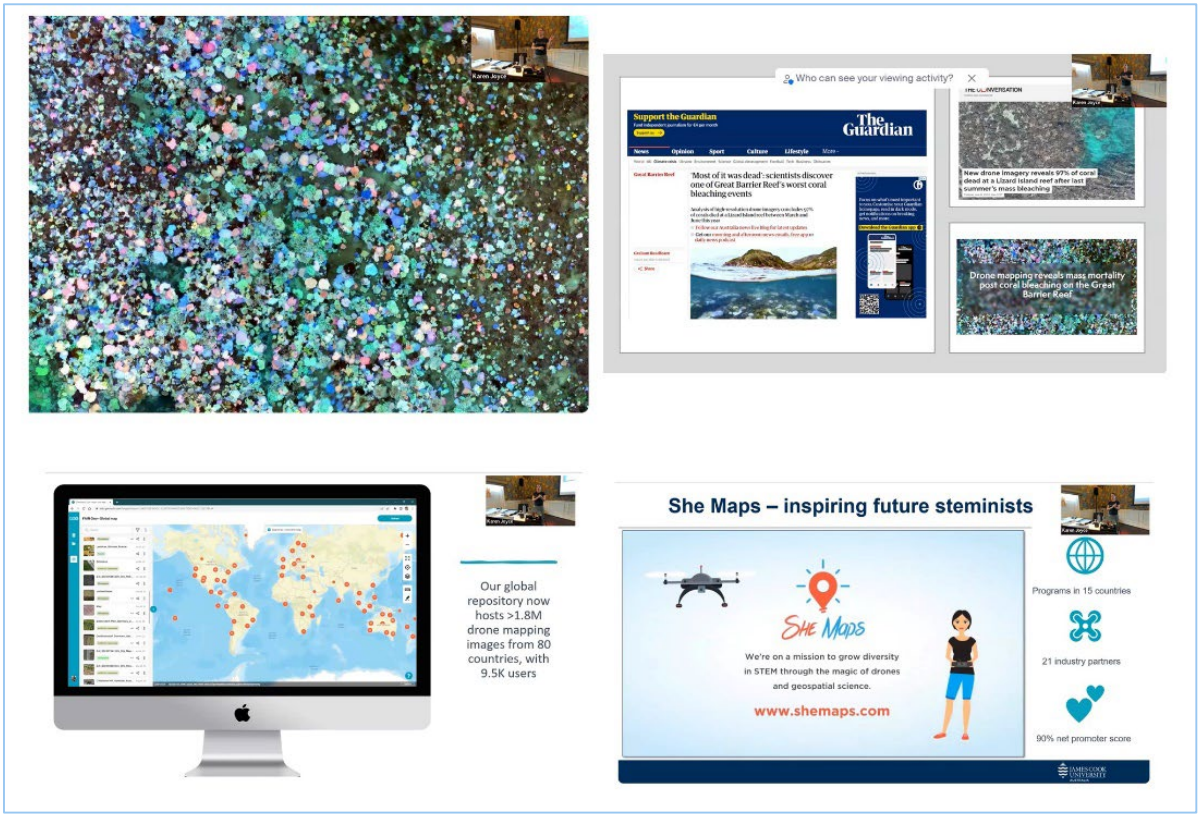

Fig. 3. Day 2. Images of the recorded keynote presentation by Karen Joyce on 27.06.2024. From top left to bottom right: i) Recent image from Heron Island, Great Barrier Reef showing high percentage of bleached corals, ii) Illustration of Joyce's involvement in the documentation of the 4th global mass bleaching event, iii) display of the global repository of available drone data via GeoNadir, iv) representation of the school training programme *She Maps* to teach school kids to use consumer-grade drones.

Following Joyce's talk, we welcomed Oda Ryggen, who joined online representing the underwater drone and ROV manufacturer Blueye from Norway. Ryggen presented a comprehensive overview of the instruments commercialised by Blueye, and also organised a live demonstration of a functioning portable ROV. A field operator joined the online talk live from a costal location in Norway, and deployed the ROV, showing the footage captured by the ROV to all workshop participants (Fig. 4).

In addition, Costa-Pinto presented the company Globhe (Sweden), which is an on-demand drone data platform designed to facilitate the collection of drone data throughout a network of >11.000 certified drone operators distributed in 147 countries in the world. Globhe offers a centralised platform to commission drone data acquisition with the desired specifications anywhere in the world. This circumvents the challenges researchers often find when operating drones abroad require lengthy or costly processes to comply with local regulations.

Also in this session, we welcomed Lehmann representing Optoprecision and the German Aerospace Centre. Lehmann introduced the novel larger drones equipped with a variety of sensors to complement the collection of imagery with the measurement of water quality parameters for advanced oceanographic research.

Unfortunately, although we originally planned to have a better representation of the drone manufacturing sector in the workshop, and had invited two more companies, our invitation was

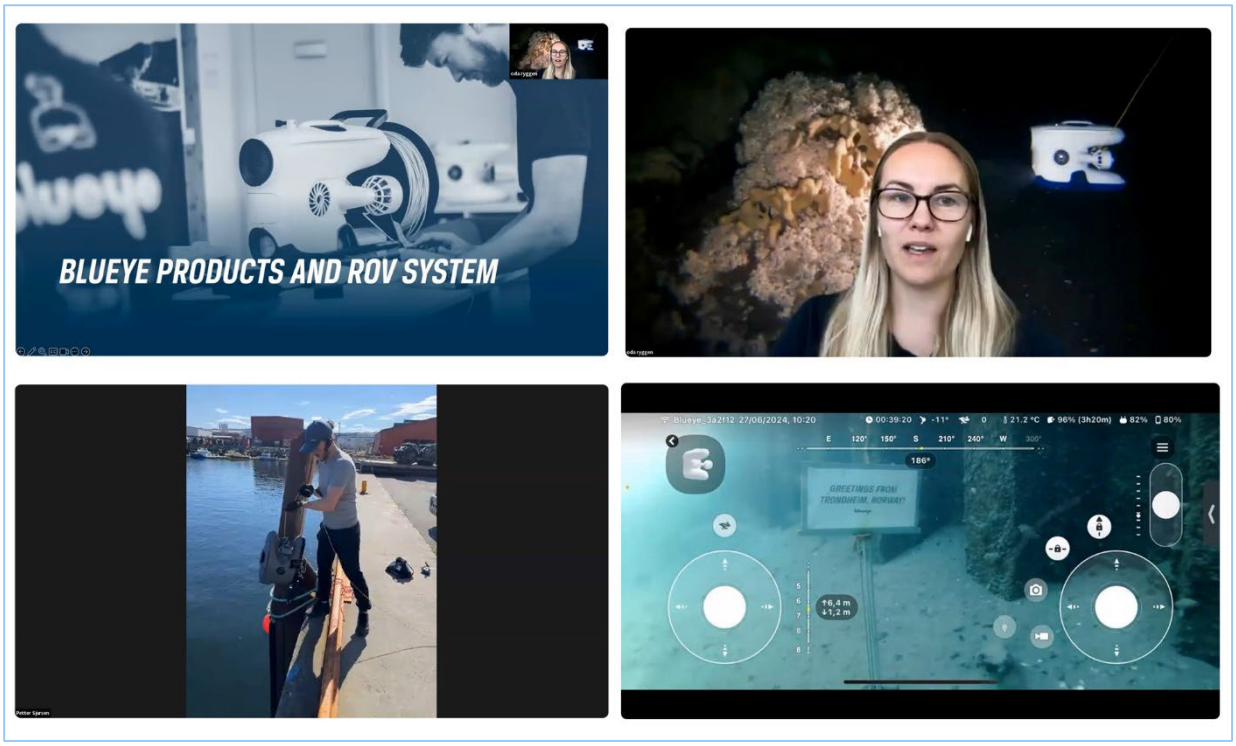

Fig. 4. Day 2. Images of the recorded presentation by Oda Ryggen on 27.06.2024. Bottom slides show the live demonstration of a functioning underwater drone.

declined. Further, the speaker who had confirmed his participation to deliver a comprehensive presentation on the legislation of drone use (Jan Evers) unfortunately cancelled his participation last minute due to illness. To compensate this, one of the presenters put together a presentation regarding the legislation that regulates drone operations in a key tropical partner country of ZMT (i.e., Colombia).

Two more scientific presentations rounded up the programme on Day 2. Kersten and Schnurawa presented an exploration of the feasibility of integrating drone surveys into regular monitoring activities weighing pros and cons. They also presented a range of consultancy services offered by BioConsult, including permit processing, and the use of drones for diverse mapping objectives including benthic mapping and monitoring of large mammals (seals) coupled with the automated analysis with machine learning algorithms. Further, Romagnoni and Dudeck presented the results of their collaborative project aimed at monitoring of Caribbean reef fish abundance using a combination of optical and acoustic sensors.

1.2. Interactive work sessions on the joint manuscript

Across three work sessions during the workshop the presenters and organisers came together to discuss possible outlines for a joint publication based on the background laid by the presentations. By the end of the workshop we assembled a comprehensive “brainstorming” document on which each presenter contributed concrete ideas. Each participant outlined the main knowledge gap from their perspective and area of expertise, as well as specific contributions they could share to the concepts put forward in the perspective paper (e.g., datasets, case studies, expert insights). In parallel, we prepared a draft manuscript document in a shared folder, crafted a tentative title as well as tentative subtitles for six subsections, each with a designated leading writer. We jointly decided on the lead authors of the entire manuscript and scoped a series of potential target journals. Rovere, Casella and Bejarano are leading

the writing of this manuscript and the writing is ongoing. The first draft is planned by September 2025 and submission is planned no later than 15.12.2025. Ultimately, this manuscript will consolidate the collaboration between and within writing teams and will facilitate the identification of knowledge gaps and potential future directions to work on joint proposals. The title of the paper is *Unlocking the potential of consumer-grade drones for coastal and marine research* and it will contain six sections as follows i) *The potential of drones is superior to other imaging tools*, ii) *Standardising data collection methods*, iii) *Achieving the best possible metadata documentation*, iv) *Improving data accessibility, reusability, and integration across disciplines*, v) *More and better financial and government support*, vi) *Towards a globally-coordinated observation system*.

2) Please describe the milestones and deliverables achieved.

ID	Milestones (as in original proposal)	Status
1	Concretisation of the agenda of the workshop.	Achieved
2	Establish a communication and outreach strategy including social media presence that can be implemented throughout the development of the workshop and delivery of outputs.	Achieved
3	Finalise travel arrangements for all participants.	Achieved
4	Co-develop working documents and interactive tools as basis for scientific work during the workshop and cloud space for data sharing.	Achieved
5	Complete the workshop and store main collective outputs in shared cloud space.	Achieved
6	Finalise and submit collaborative proposal within the framework of the UN Ocean Decade to be endorsed by UNDOS.	In progress. A collaborative proposal will be prepared on the solid bases of knowledge gaps defined and reflected upon in a perspective paper in preparation
7	Finalise workshop proceedings identifying the main axes of cooperation among the scientific community, aviation authorities and the consumer-grade drone development industry to facilitate solution-oriented drone-based research.	A summary of workshop outputs has been compiled, a brainstorming document compiling ideas to include in a draft scientific manuscript was also finalised. All presentations have been recorded.
8	Finalise state-of-the art guidelines for drone operations for marine and coastal drone-based research compliant with national and international legal regulations and optimised for scientific data management based on the 'FAIR' criteria.	This is ongoing as part of the ZMT scientific strategy developed jointly with the ZMT Directorate. Sections within the planned joined manuscript address this deliverable.

3) Is this Working Group likely to continue to meet beyond the dates outlined in the original proposal?

The manuscript leads and workshop organisers Rovere, Casella and Bejarano, meet regularly to discuss the scope and progress of the manuscript. Once a draft is finalised, we will organise at least two follow-up meetings with all the paper co-authors (workshop presenters) to present and finalise the draft. Once the manuscript is accepted, the leads of the manuscript (Rovere, Bejarano and Casella) will draft a strategy for the preparation of a joint proposal and will organise meetings with the presenters to establish the potential scope and funding instrument. The manuscript leads continue in frequent contact in case the opportunity for a joint proposal emerges.

4) Please provide your comments on the POGO-funded Working Group Initiative (e.g. has the funding made a significant difference in the progress of this Working Group?).

Without the funding we could have not facilitated the broad exchange between the scientific research community, drone manufacturers, developers of new sensors and technologies, as well as with teams that are up-to-date with the fast evolving legislation regulating the use of drones in different countries. Not only will this allow us to significantly advance the jointly identified knowledge gaps, but to meaningfully contribute to the improved quality and reach of Earth Observation systems.

Please return completed form by e-mail to pogoadmin@pml.ac.uk and enclose a copy of the Workshop report, if applicable.