JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

Science, Services, Sustainability

DELIVERABLE #, WP# and full title	JERICO-S3 D.10.5 - WP10 - "Report on training workshops including production of guidelines on best practices aimed at staff training"
5 Key words	Training workshop, Flow Cytometers, High Frequency Radars, best practices, coastal observation
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Final version date/ Submission date	29/07/2024

Nature: R

(R = Report, P = Prototype, D = Demonstrator, O = Other)

Dissemination level : PU

PU = Public, PP = Restricted to other programme participants (including the Commission Services), RE = Restricted to a group specified by the consortium (including the Commission Services), CO = Confidential, only for members of the consortium (including the Commission Services)

GRANT N°: 871153
PROJECT ACRONYME : JERICO-S3
PROJECT NAME : Joint European Research Infrastructure for Coastal Observatories - Science, services, sustainability
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DOCUMENT TECHNICAL DESCRIPTION

Document ID	JERICO-S3-WP10-D10.5-29.07.2024-V1.0

REVISION HISTORY

Revision	Date	Modification	Author
V1.0	29/07/2024	First version	Carlo Mantovani, Veronique Creach, Joao Vitorino, Vânia Lima

APPROVALS

	Name	Organisation	Date	Visa
Coordinator	Delauney Laurent	Ifremer	29/07/2024	X
WP Leaders	Joao Vitorino	IH	29/07/2024	X

Diffusion list

Consortium beneficiaries	Third parties	Associated Partners	other
X	X		

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1. EXECUTIVE SUMMARY

The present deliverable provides reports of training workshops organised within Task 10.4 of JERICO-S3 and aimed at enhancing the community through skill development and knowledge transfer. Thanks to the experience gained through these workshops' organisation and attendees feedback, this deliverable also provides some general guidelines aimed at future staff training in the context of JERICO RI facility management.

Two training workshops were planned at the beginning of the project:

- the Training Workshop #1 (JERICO MS60) was focused on High Frequency (HF) Radars data management and QA/QC practices, and was organised by Consiglio Nazionale delle Ricerche (CNR), Italy, and AZTI, Spain. The workshop was co-financed by LaMMA consortium (Italy) and organised as side event of the MONGOOS annual workshop;
- the Training Workshop #2 (JERICO MS64) was focused on harmonisation of the analyses of the in situ flow cytometry, and was organised by CEFAS and CNRS-LOV.

A third workshop, not foreseen in the DoW, was nevertheless co-organised by CNRS (MIO/LOG-ULCO), Cefas, and SYKE thanks to the co-financing of Euromarine and the European project OBAMA-NEXT (Horizon Europe, ID: 101081642). It was focused on a similar topic as the previous workshop #2, i.e. flow cytometry data management.

The summary of these workshops is presented in section 3.1 and 3.2 respectively, general guidelines for training are discussed in section 5, and conclusions are provided in section 6.

2. INTRODUCTION

Training courses and training tools are key components in maintaining and evolving practices, and are themselves one of the requirements that define best practices (Mantovani et al. 2024, in press). Training operators is essential for harmonising operations within a network of facilities, particularly in complex and high-tech environments like European Research Infrastructures, because it ensures consistency in standardised procedures, leading to reliable results and effective collaboration. It optimises resource utilisation by enabling efficient use of equipment and avoiding redundancies. Uniform quality standards and reduced errors enhance quality assurance. Training enforces safety protocols and regulatory compliance. It facilitates the integration of new facilities and operators, supports problem-solving and innovation through shared knowledge, and promotes cost efficiency in training and operations. Consistent training ultimately enhances overall efficiency and success in achieving the network's research goals.
In the context of JERICO, around 40 deliverables containing recommendations and best practices have been produced by JERICO projects during the last ten years.
Once practices are well developed and documented, new users need training material to properly implement those practices. Suitable training programs supported by training tools become necessary for enhancing the community through skill development and knowledge transfer, ensuring that best practices are disseminated and hopefully implemented (Pearlman

et al., 2019). Training programs, gathering together experts and new users, represent also an important opportunity to receive feedback on existing practices, which is in turn a key step in assessing and evolving the practices themselves.
The training workshops described in this deliverable, which were also accessible to external participants, were aimed at disseminating best practices focusing on data management, data processing, and QA/QC procedures within JERICO facilities, thereby facilitating knowledge transfer within the consortium.

3.WORKSHOPS REPORT

3.1.Workshop #1: HF Radar

3.1.1. Introduction

In oceanography, High-Frequency (HF) radar is a remote sensing technology employed for monitoring ocean surface currents and waves. Operating in the HF radio frequency band, these radar systems extract sea state and current information from the Doppler shift induced by the movement of the ocean surface. They are typically deployed in networks along coastlines, thus providing information in coastal zones up to 200 km from the shoreline.
In 2014, EuroGOOS initiated the HFR task team to advance the establishment of an operational HFR network in Europe. The focus was on coordinated data management, integrating basic products into major marine data distribution platforms. A core group of this task team was then involved in a series of projects that supported the development of guidelines for HFR surface currents data management (Lorente et al., 2022).
Among those projects, JERICO-NEXT and JERICO-S3 have greatly contributed to strengthen the HFR community in Europe, to define a series of best practices (Corgnati et al., 2024; Mantovani et al., 2020) and to develop a series of operational tools for HFR data processing and management, to ensure HFR data compliance with international standards and with already available and widely adopted recommendations within the international HFR community. There is a recognized need to disseminate such best practices through a training programme on HFR technology that encompasses all identified aspects, from instrument maintenance to data analysis and management.

3.1.2. HFR workshop description

The Training Workshop #1, focused on HF Radars, was organised by Consiglio Nazionale delle Ricerche (CNR), Italy, with AZTI, Spain, both partners of JERICO-S3 and both coordinating WP5 (Harmonisation of integrated Multiplatform & Multidisciplinary systems). The workshop, titled "New Joint Tools for the European HFR Community," took place in Florence, Italy, from November 21-22, 2022. It was conducted in both remote and in-person formats, with approximately 15 participants attending in person and another 15 joining online (figure 1). This Training Workshop was part of the periodic meeting of the High Frequency Radar (HFR) Task Team of EuroGOOS, was was co-financed by LaMMA consortium (Italy) and organised as side event of the MONGOOS annual workshop.

Figure 1 - HFR workshop attendees group photo.

This specialised workshop was open to both project partners and external participants and focused on the topics described as follow:

- an example of service in the JERICO Coastal Ocean Resource Environment (CORE) Virtual Research Environment (VRE), implemented under JERICO-S3 WP7 (Technological Innovation), was presented, helping to show the prospect of this platform for the HFR community and the gaps in the HFR information of the JERICO-CORE resource catalogue;
- a practical step by step demonstration was aimed at introducing the HFR Online Outage Reporting Tool (HOORT) user interface, key features and functionalities to the European HFR operators. The tool is intended to provide guidance for detecting, describing and archiving in a searchable database all the outages occurring in operational HFR networks, sending near real time data to the European HF Radar Node;
- a detailed overview of the Quality Control procedures and the related software tools operated by the European HFR Node for the production and distribution of standardised Near Real Time (NRT) and Delayed Mode (DM) surface current data, measured by High Frequency Radar systems, was presented and explained.

During the first day of the workshop, the topics and tools were presented through conventional online and remote presentations. On the second day, most of the tools presented were the subject of a practical training in which practitioners were able to experience the basic use of these tools directly from their computers.
Other details are available on JERICO-S3 MS60. All the tools are described in JERICO-S3 deliverable 5.5. (https://www.jerico-ri.eu/download/jerico-s3_deliverables/DL5.5_JERICO-S3-D.5.5-WP5-functional-homogenization-tools-31-03-2023.pdf)

3.1.3. Conclusions of HFR workshop

The tools proposed during the training workshop had a different level of maturity, some were established and others had just been developed or were under development. This lack of homogeneity gave rise to different levels of user satisfaction. On the one hand, for example, there was widespread interest in the HOORT tool, which was presented for the first time in a training course. This tool received feedback for its improvement from new users after the workshop. On the other hand, both due to its not yet mature stage of development (and the lack of training manuals) and its greater conceptual complexity, the training on JERICO-CORE VRE was difficult to follow. Users reported that the documentation in general, where available, was not sent sufficiently in advance of the workshop, and also that some registration operations on the digital platforms used (HOORT, Blue-Cloud) had to take place earlier, in order to avoid malfunctions and difficulties in following the training.
The fact that most trainers were remotely connected was a great disadvantage, as there were some communication problems, the contact was not so straightforward and delayed/disturbed.
All the topics covered in the workshop were however of great interest to the participants, as they responded to needs that emerged consistently in the discussion at European and international HFR network level, and the duration of the training was adequate, as well as the technical setup.

3.2.Workshops #2 and #3: Flow cytometer

3.2.1. Introduction

The two workshops organised in the framework of JERICO-S3 with additional financial support of Euromarine and in collaboration with another EU project (OBAMA-NEXT, Horizon Europe, ID: 101081642) aimed to harmonise the analyses of the in situ flow cytometry and rapidly deliver with confidence datasets for monitoring and modelling purposes. These workshops are aligned with the Global Ocean Observing System 2030 Strategy as it is based on sharing experience, training early career ocean professionals and collaborating between diverse scientific communities for better observing and preserving the resources of our seas (SDG 14). Based on improving the data flow from instrument to predictive modelling, the workshops were a step towards the digital environment (Digital Twin of the Ocean: DITTO) which will be the key component for ocean and water monitoring and foresight.
If today, environmental variables like chlorophyll can be remotely determined, this type of measurement can generate large uncertainties (Brewin et al., 2017), making it sometimes difficult to use models for reconstructing or forecasting either biogeochemical or food web processes. Therefore, in situ observation is needed more than ever to make our predictions more accurate and faster. In the case of phytoplankton, the best way to sample the phytoplankton community is to reach the observation at the single cell, identify its belonging functional group and follow its dynamics at the daily scale. Sampling at the single cell level and at the hourly scale from in situ collected samples or automatically via flowthrough systems is possible with automated flow cytometers (FCMs). Large data sets have been already collected all around the world to describe different microbial communities in different pelagic habitats. These data are difficult to find and consequently to share. The lack of best practices at the sample collection, data analysis and management levels as well as a clear path to the database are the main barriers. In the framework of SeaDataCloud (Horizon 2020, ID:

730960) and JERICO-S3 (Horizon 2020, ID: 871153), important steps have been reached with the establishment of a data flow to SeaDataNet and the publication of a common and interoperable vocabulary (Thyssen et al., 2022). The two workshops were opportunities for the FCM users to learn the new best practices, improve and apply new processes for data analyses, and be aware of a possible path for managing their data.

3.2.2. Flow Cytometer workshops description

The first training workshop entitled "*Improving the data flow of plankton images to EcoTaxa*", was co-organised by CEFAS and CNRS-LOV, and took place at the Observatoire Océanologique de Villefranche-sur-Mer laboratory in France, between June 13th and June 15th, 2023. It was focused on the Best Practice for Imaging Data Management, more specifically planktonic imagery data management and processing (WP9). Practical sessions for using the EcoTaxa which has been implemented in the JERICO e-infrastructure (https://www.jerico-ri.eu/va-service/ecotaxa/) were organised. The main targets were the data management and processing pipelines to EcoTaxa, training on Ecotaxa, and export from EcoTaxa to EMODnet biology. The participants to the workshop have been required to possess coding skills in R and Python to establish the new pathways for the CPICS (*in situ* zooplankton imager) and the Cytosense (*in situ* flow cytometer with imaging capabilities). More details of the workshop can be found in JERICO-S3 MS64.

The second training workshop entitled "*TT-CYTO: Tips and Tricks towards flow cytometry data FAIRness*" was co-organised by CNRS (MIO/LOG-ULCO), Cefas, and SYKE. It took place at the Laboratoire d'Océanographie et de Géosciences at Wimereux in France, between June 4th and June 6th, 2024. Between 28 and 31 FCM users participated in person and 6 and 9 followed the presentations online (figure 2).

Figure 2: *TT-CYTO* workshop attendees group photo.

During the workshop, the participants identified and labelled the different phytoplankton functional types (PFTs) to build training sets characterising different ecological areas of interest. The training sets were used in machine and deep learning approaches (random forest or conventional neural network), not only already established before but also initiated after the first workshop. This second workshop was built with a series of presentations, training exercises as well as exchange of experience and ideas from FCM users. The first day of the workshop focused on **homogenisation of manual gating following guidelines, inter-users' comparison, inter-sampling site comparison, and blind tests.** It was the first trial to evaluate the discrepancy between flow cytometer users on classifying the phytoplankton functional types (PFTs) using the vocabulary (Thyssen et al., 2022), the best practices and conceptual cytograms which have been demonstrated by the experts previously. The definition and best practices for gathering were tested by clustering PFTs from cytogrammes from three different areas (Baltic Sea, Mediterranean Sea and Channel/North Sea). The second day of the workshop focused on presenting **tools and approaches to automatic clustering and imagery (Ecotaxa)**. Because the manual gating is time consuming and error-prone, the flow cytometry community is expecting to have reliable automated analysing processes. Since the last 2 years, advances in flow cytometry automated classification have gained power by applying machine and deep learning processes (Fuchs et al., 2022). The use of such models requires strong training sets of selected groups, which can only be built by experts or trained users based on consensual guidelines in flow cytometry manual gating. Thus, intercomparing data sets and classical manual classification is still required, especially when automation is expected. During the second day, the FCM users used available software (EasyClus) and installed random forest and neural network scripts to apply to their data. Additionally, Ecotaxa tool and short-term perceptive to ingest images from Cytosense were presented. The third day of the workshop aimed to show examples of established **FAIR databases** for marine flow cytometry dataset: SOMLIT (French National Databases for coastal observation) and CytoBASE linked to SeaDataNet from CNRS-MIO. The workshop ended with 3 presentations of deployments of FCMs, as well as scientific highlights and a general discussion.

A feedback questionnaire was sent after the first and second day of practical exercises.

Question1: How do you feel directly after this day?

> <u>4th of June</u>: the participants gained in confidence using the vocabulary and doing the clustering of the PFTs after doing the exercises and discussing with the experts. They learned the different functionalities of the software CytoClus. However, a lot of information were given, and some participants were tired also because they travelled the same day.
>
> <u>5th of June</u>: the participants were motivated, think that it was very good and interesting. They got a new knowledge on FCM data handling and excited to apply what they have learned.

Question 2: How helpful was today from 1 (not helpful) to 10 (very helpful)?

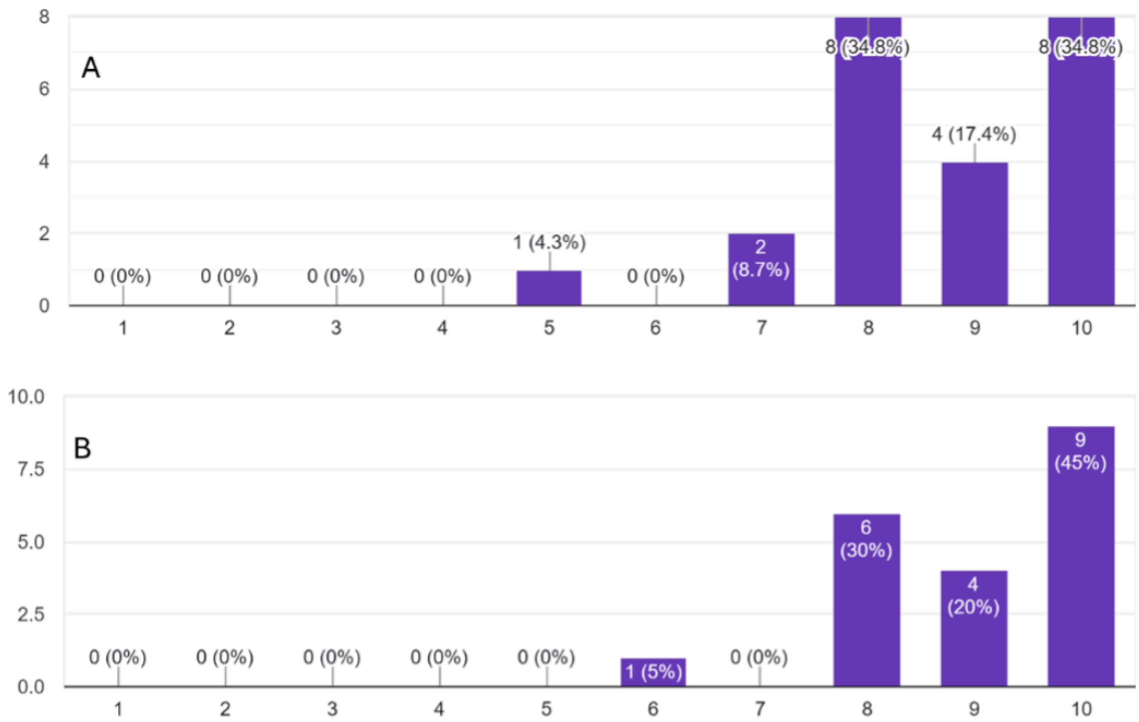

Fig 3: Answers to the question "*How helpful was today from 1 (not helpful) to 10 (very helpful)?* " A: answers from the 4th of June 2024; B: answers from the 5th of June 2024.

Question 3: Did you get new insight(s) from today's sessions? If so, which insight(s)?

> <u>4th of June</u>: the participants were satisfied to learn more about the software CytoClus, best practices before acquiring samples (beads, trigger level, coincidence) and manual clustering and vocabulary.

5th of June: the participants were satisfied to have seen and tried the different approaches for clustering from manual to automatic (EasyClus, random forest, conventional neural network) and image recognition tool (Ecotaxa).

Question 4: Did you feel we did not discuss something during the session? If so, what did you miss?

4th of June: The participants missed support documentation for the exercises and discussion on biovolume estimation, the limit of the PFTs clusters and other functionalities from CytoUSB.

5th of June: The participants suggested building tutorials to help the FCM users.

To conclude the workshop, the participants were invited to share their ideas for improving the data acquisition, data handling and data management using an online tool. The answers are listed below:

Data acquisition:

Instrument: Improve user manuals for CytoSense by implementing information for regular maintenance (e.g. operational standard procedures for changing tubing, rinsing, volume standardisation, sheath fluid change, beads replacement, cuvette cleaning, alignment core, camera and laser...).

Best practices: Establish common protocols for sampling, measurement including beads for converting fluorescence and forward scatter to biovolume/carbon and size.

Data handling:

Instrument: provide training in CytoClus for new users by an experienced user. Improve user manuals for CytoClus software.

Best practices: Develop a nomenclature for beads, bubbles, noise and background, collaborate with data scientists to improve automated classification methods, define a common clustering for PFTs.

Data management:

take advantage of the existing pipeline and advertise it with the FCM community through scientific publication.

3.2.3. Conclusions of flow cytometer workshops

Despite the efforts already made with the vocabulary and the data pipeline, the two workshops showed the need for further guidance in acquisition and data processing of in situ flow cytometry. Without further initiatives from the flow cytometry and data scientist community, it would be still difficult to share data sets and describe the changes of the phytoplankton community at the global scale with confidence. After the first workshop dedicated to data flow, it became obvious that a collaboration with data scientists is essential to develop automatic clustering. Following the first workshop, development of an API as well as a conversion process to JSON file has been done. By having direct access to the FCM data from the instrument and a conversion pipeline to JSON or CYTO, it is now possible to develop or apply new machine learning or deep learning processes. However, automatic processes rely on training sets and validation steps which can only be performed by experts. During the second workshop, the large discrepancy between users to define the PFTs has been seen despite a previous guidance. Establishing best practices for acquiring good data, clustering, and providing quality control scale need to be discussed with a network of experienced users as soon as possible. Building a strong network between new and existing users is essential for training and communication purposes. It will also open opportunities to meet and build together strong knowledge in in-situ FCM. Finally, but not the least, a dialogue with the companies building FCMs should be improved to be able for them to answer to the needs of the operators and scientists on a more regular basis.

4. OUTREACH, DISSEMINATION AND COMMUNICATION ACTIVITIES

The HFR workshop was advertised on the JERICO-RI website (https://www.jerico-ri.eu/2022/11/29/eurogoos-hfr-task-team-annual-meeting/) and social media pages (such as, e.g., the JERICO-RI LinkedIn page https://www.linkedin.com/events/jerico-s3trainingworkshop-newjo6999075388496703488/comments/) and on the Copernicus Marine Service In-Situ Ocean TAC website (https://marineinsitu.eu/eurogoos-hf-radar-task-team-annual-meeting-jericos3-training-workshop/).

The 2 Flow Cytometer workshops were advertised on JERICO-RI website (https://www.jerico-ri.eu/events/tt-cyto-tips-and-tricks-towards-flow-cytometry-data-fairness/) and EUROMARINE, OBAMA-NEXT websites (https://euromarinenetwork.eu/activities/TT-CYTO/ and https://obama-next.eu/register-now-for-the-tt-cyto-tips-and-tricks-towards-flow-cytometry-data-fairness-workshop/) and by direct contact using the mailing list of the FCM company (Cytobuoy) for the second workshop. The two workshops did not target the same scientific community. If the first workshop targeted data scientists, the second workshop was open to engineers, technicians, students and scientists with different levels of experience in FCM. No communication plan has been discussed after the first workshop as it was a very technical workshop aiming to unlock data issues. During the second workshop, the participants have expressed the need to keep in contact for exchanging their experience and their ideas, troubleshooting, progressing in their data handling and management. Some ideas have been discussed:

Short term communication

- Advertise the main conclusions from the workshop using the main websites already cited and the company website.
- Make available the presentations of the workshop and the results of the intercomparison exercise between FCM users (already happening with the collaboration of the FCM company to the Chinese partners).
- Communicate the GitHub link for BODC to implement new reference and definition for flow cytometry, the GitHub link to have access to the conversion file pipeline to JSON and CYTO.

Long term communication

- Use existing programmes to meet regularly (at least every 2 years).
- Set up a summer school in a European programme.
- Set up a FCM forum to exchange recommendations and experience by reopening the customer forum and/or opening a Slack group.

- Create a common space to exchange files.
- Participating in existing working groups such as ICES Working Group on Phytoplankton and Microbial Ecology (WGPME) and/or the Biological Working Group in EuroGOOS.
- Write proposals to support the best practice activities, the development of automatic data processes, as well as exchange the scientific knowledge on phytoplankton diversity in different water bodies with other scientific communities (e.g. remote sensing and modelling).
- Continue to communicate with the European data infrastructures such as EMODnet and SeaDataNet to agree on a data pipeline which can be used directly by the operator or by the scientific organisation.
- Write a scientific publication about best practices on high frequency FCM measurements.

5. GUIDELINES FOR STAFF TRAINING

The importance of training in ocean practices has been emphasised in the general context of evolving and sustaining best practices (Pearlman et al., 2019 and 2021), However, these best practices do not necessarily have training materials or tools, an issue that needs to be addressed.

As said previously, around 40 documents containing recommendations and best practices have been drafted during the last 10 years in the context of JERICO projects, however training materials and activities were not organised in a comprehensive and structured manner. Training operators in JERICO is crucial for harmonising operations within a network of facilities, and should be pursued with a structured training program. This section aims at providing first recommendations for opening a discussion on the subject.

While traditional in-person training has been, and can be, replaced in many instances by online training and digital resources, an optimal strategy combines both methodologies. The predominance of one over the other should be assessed case by case, considering their respective pros and cons.

In-Person Training is ideal for hands-on learning, immediate feedback, and networking but can be logistically challenging and resource-intensive.

Online Training offers flexibility, accessibility, and cost-effectiveness but may lack practical experience and face-to-face engagement. In real time sessions, technical issues may prevent users from full exploitation.

The experience gained from the three workshops described in this deliverable confirms these considerations. In the cases where participation was mixed (some users or experts were online and others were in attendance), and the training involved the use of real-time interactive software tools, the difficulties in making the course interactive and easily usable were more evident. The lesson learned is that careful planning and testing of the technology should be performed in advance, and a sufficient time for hands-on exercises has to be allocated.

In the table below, a list of general suggestions is provided as a starting point for defining the JERICO good practices related to staff training.

Table 1 - suggested elements for implementing a JERICO structured training programme

Element	Description
Training needs identification	● Conduct a gap analysis to identify the specific training needs related to ocean observing sensors, data acquisition platforms, data management, ocean processes understanding. ● Identify available good or best practices and related training material that can support training. ● Ensure training goals align with the JERICO scientific and operational objectives.
Set clear objectives	● Specify what trainees should know and be able to do after the training, such as operating specific sensors or managing marine data. ● Establish clear, measurable objectives to evaluate training effectiveness.
Develop a Comprehensive Training Program	● Design a modular program covering theoretical knowledge, practical skills, safety protocols. ● Tailor training materials to address the specific technologies and methodologies used in your ocean observing platforms. ● Evaluate and allocate proper duration and resources. ● Ensure consistency and coordination with broader networks and working groups (e.g. GOOS; EuroGOOS; EMODnet; Copernicus; ENVRI), taking advantage of other existing or planned events for maximising the impact of the training.
Hands-On and Practical Training	● Incorporate hands-on training at sea to provide real-world experience with sensors and data acquisition platforms. ● Use simulations to practise scenarios such as sensor deployment, data collection, and troubleshooting.
Leverage Technology for Training	● Develop online digital contents allowing flexible learning schedules. ● Utilise virtual labs and virtual research environments for remote hands-on training on data processing and data visualisation algorithms (e.g. https://www.d4science.org). ● Investigate JERICO-CORE (https://www.jerico-ri.eu/va-services/jerico-core/) capabilities and/or other JERICO and non JERICO digital services for providing training platforms and resources, such as the OceanTeacher Global Academy (OTGA) (https://classroom.oceanteacher.org/), the ENVRI community Training platform (https://training.envri.eu/), the Blue-Cloud Training Academy (https://blue-cloud.org/training-academy), the Copernicus Training Academy

	(https://www.copernicus.eu/en/opportunities/education/copernicus-academy) and EMODnet dedicated training sessions (e.g. ocean data, other topics). ● Ensure interactive content to maintain engagement.
Continuous Learning and Development	● Offer regular refresher courses to keep skills up to date as technologies and methodologies evolve. ● Keep contacts with instruments' manufacturers to be able for them to answer to the needs of the operators and scientists on a more regular basis.
Evaluate and Provide Feedback	● Use quizzes, practical tests, and performance assessments to evaluate trainees' understanding and skills. ● Implement regular feedback mechanisms to identify areas for improvement and enhance the training program. Possible questions are: in which way was the training useful (new insights provided, satisfactory training material); was the documentation sufficient; was the communication/advertising sufficient; was the subject of the training framed with sufficient clarity in the context of the Research Infrastructure and its scientific and operational objectives (e.g. how sensor technology or methodology is positioned and used inside JERICO); which are the major outcomes of the training (how did you change your practices after the training -> nothing/ minor changes/ major changes/ other); suggestions for improvement; suggestion for specific topics for future training.
Safety and Compliance	● Emphasize safety protocols and procedures relevant to oceanographic fieldwork and equipment handling. ● Include training on regulatory requirements and ethical considerations in marine research.
Documentation and Reporting	● Maintain detailed records of training sessions, attendance, and performance evaluations. ● Provide regular reports on training outcomes to stakeholders and use the data for continuous improvement. ● Ensure trainees have access to necessary resources, including manuals, reference materials, and online tools.

Discussing these guidelines is important for designing structured and JERICO-tailored training programs, ensuring that personnel are well-prepared to operate equipment, acquire data, and manage information in a standardised and efficient manner.

6. CONCLUSIONS

Three training workshops have been organised within JERICO-S3 - Task 10.4 -, co-financed by a joint collaboration of other projects and bodies. The workshops were focused on High Frequency Radars and Flow Cytometry and aimed at enhancing the community through skill development and knowledge transfer. Reports of these workshops have been produced, including context, topics covered and, where available, feedback from participants and organisers. These experiences, together with an analysis of available training tools and platforms for ocean practices, have enabled the formulation of a series of elements considered important for structuring a staff training programme within JERICO, to be discussed in future JERICO development.

7. ANNEXES AND REFERENCES

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