uBlueTec - Training Framework on Underwater Tecs as Key Enabler for Blue Careers Development

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***Abstract*—While Blue Economy remains a fundamental sector in many world economies, its needs and impacts require specialized skills. For the sustainability of blue economy sectors, both technical skills (blue and digital) and green skills are needed. Identifying a skills gap, the uBlueTec project aims to set up, test and validate a triple transition training and skills development model (green, blue, digital skills). Through a durable partnerships among universities, VET providers, clusters and Small and Medium Entreprises (SMEs), the project will developed curricula and implement pilots both for VET and Higher Education levels. The article describes the skills gaps analysis and preliminary work on the curricula.**

***Index Terms*—underwater technologies; robotics education; VET training; blue economy; blue skills; digital skils**

I. Introduction

Blue Economy is a fundamental sector, and its sustainability has effects in all pillars of society and citizens' wellbeing. Seas and oceans cover more than 70% of Earth's surface. According to EU Blue Economy Report 2022 [1], the EU Blue Economy directly employs about 4.45 million people and generates around €667.2 billion in turnover. On a global scale, the ocean economy has an estimated turnover of between US$3 and 6 trillion. This includes employment, ecosystem services provided by the ocean, and cultural services. In particular, fisheries and aquaculture contribute $US100 billion per year and about 260 million jobs to the global economy [2]. The ocean is being used more intensively than ever leading to global challenges: climate change impacts, need for new sources of clean energy, job creation and inclusive growth. But managing such maritime economic activities & exploiting (sustainably) the ocean resource requires the update of ocean-related knowledge. For example, the Commission estimates that reaching the 2050 zero carbon goal will require a quarter of Europe's electricity to be generated offshore.

A range of new digital technologies for commercial and scientific applications such as: artificial intelligence, big data, complex digital platforms, blockchain, drones, sophisticated arrays of sensors, small satellites, genetics, acoustics, seabed mapping, remote sensing etc.., are contributing in important ways to the sustainable development of the ocean economy. Evidently, our seas have the potential to deliver sustainable growth and jobs in the coming years and contribute towards the EU Green Deal and the objectives of UN's Ocean Decade. But to strike the balance among economy and maritime activities, marine ecosystem preservation, sustainable growth and the need to expand ocean knowledge, skillful people with the right green and digital blue skills are needed, capable of contributing to the green/blue transition. The European Commission, in Skills and Career Development section of Blue Economy [3], identifies that this balance can be achieved only if we invest in new blue skills and career development. Yet today, many blue economy sectors have difficulties finding the right people, affecting their growth due to the mismatch between current academic/Vocational Education training /(VET) provision and the needs of the EU Blue Economy. The appropriate blue, digital and green skills, the respective market needs, and technological advancements run with a faster pace compared to the existing academic and/or VET training programmes (skill providers) leaving behind those that cannot follow.

II. Project Overview

Motivated from these considerations, the uBlueTec project [4] aims to set up, test and validate a triple transition training and skills development model (green, blue, digital skills). The model we propose is based on a participatory approach with durable partnerships among universities, VET providers, clusters and Small and Medium Entreprises (SMEs); all active members of blue economy value networks;

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and all valuable links in the foreseen value-chain of the uBlueTec skills-development model.

In particular, the uBlueTec project has the following main objectives:

1) Development of educational material and curriculum, linked to microcredentials, and enabling skills-building in state-of-the art Underwater technologies from a green/digital perspective.
2) Piloting the developed assets at Higher Education (HE) & VET levels.
3) Establishment of a Hub on Underwater Technologies, as a permanent capacity-building structure nurturing the long-lasting collaboration of the involved stakeholders.
4) Deployment of recruitment platform for blue jobs offering online courses and facilitating demand-supply matching between current/future labour force and industries, while intelligently identifying and publishing the skills-gap at regional-national-EU levels.
5) Attraction of young talents in terms of Career Days and Entrepreneurial Bootcamps.

The uBlueTec project is one of eight projects approved by the European Maritime, Fisheries and Aquaculture fund [5] in response to the call "Blue careers for a sustainable blue economy". It has 7 partners from 6 countries including universities, VET providers and business clusters among its partners. In particular, the following partners participate in the consortium:

- Aix-Marseille University, a university from France;
- Atlantis Consulting, an SME from Greece;
- Faculty of Electrical Engineering and Computing, University of Zagreb, a university from Croatia;
- Beia Consulting International, a VET provider from Romania;
- University of Calabria, a university from Italy;
- ANP - Associação Natureza Portugal, an NGO from Portugal;
- Maritime Technology Cluster Fvg, a business cluster from Italy.

The total budget is 1 143 006.10€ and the project will last for 30 months (starting on 1st of September 2023).

III. Market needs and gap analysis

While the project is at its infancy, considerable efforts have been put to reach the objective 1). However, to develop the curriculum, the first step is to understand the needs of companies and other market actors due to the abovementioned mismatch between needed skills by the industry and offered skills by HE and VET providers. Thus, in the first months of the project, we have been focusing on identifying the market needs and gaps and best practices. Best practices will be directly identified by each partner based on their networks and previous experiences with training related to the Blue Economy. On the other hand, for the market needs and gaps identification, a questionnaire available here https://forms.gle/aLj7oKj7a9bGibu88 is being sent to companies and other market actors to understand their skills needs and the current gaps. The analysis of the questionnaires and identification of needs and gaps is extremely important to make sure that the developed curricula will effectively answer to market needs as the potential offer from the consortium is very broad covering many different topics.

During the first phase of the project, an investigation was conducted into the multiple initiatives supported by the European Union for skills deployment and training in the field of underwater technologies, with a particular focus on the blue, digital and green sectors. This comprehensive exploration aims to fill existing gaps, capitalize on previous work, and address the current lack of training tools and materials in these critical areas.

In the area of digital skills, initiatives span collaborative frameworks for underwater cultural heritage, interdisciplinary projects promoting collaboration between artists, scientists, and digital experts, and interventions fostering practical skills among secondary school students. These initiatives demonstrate a concerted effort to blend technological innovation with cultural and educational objectives.

Turning to blue skills, the EU focuses on cross-sectoral proficiency for the evolving Blue Economy. Projects encompass intelligent predictive maintenance for aquaculture systems, maritime security strategies, and initiatives supporting safety and security in the maritime domain. These efforts emphasize the cultivation of skills that align with the dynamic needs of the labour market within the Blue Economy.

In the green skills domain, initiatives contribute to the fostering of environmentally conscious vocational education and training. Efforts concentrate on integrating core green skills into curricula, supporting the green transition across various economic sectors. This includes projects that intertwine scientific activities with touristic development, emphasizing conservation and pollution mitigation.

Additionally, the EU offers a spectrum of training programs, including master's degrees, lifelong learning courses, and summer schools, catering to both digital and blue skill sets. Pilots and practical training sessions further refine competencies in areas such as underwater archaeology, remote piloting of remotely operated vehicles (ROVs), and scientific diving, ensuring a hands-on approach to skill development.

In the field of underwater robotics, a comprehensive investigation has been carried out to analyse and address the widespread challenges associated with skill gaps. This study, oriented toward the technical advancement of the field, examines the complexities of the skills needed, their current availability, and the strategies necessary to grow a qualified workforce.

A heterogeneous group of 69 entities actively participated in the survey, including SMEs, startups, academic institutions, research organizations, and governmental and nongovernmental organizations. In particular, large companies, SMEs and start-ups together made up 45% of the surveyed entities.

The survey showed strong demand for specialized skills in underwater robotics, which includes areas such as underwater vision, data processing, software development, artificial intelli-

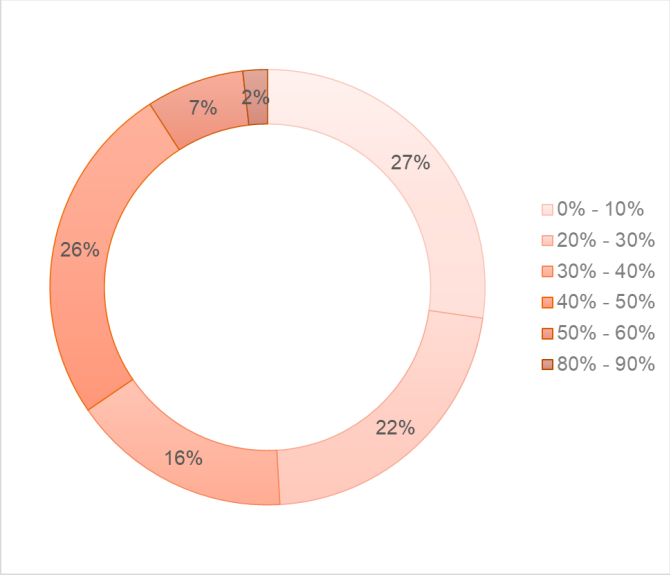

Fig. 1: Survey results: percentage of women in technical positions. Each color represents the percentage of women while the percentages on the circle represent the percentage of institutions with a given percentage of women in technical positions, e.g. 27% of institutions employ less than 10% of women among their workers while only 2% of institutions employ over between 80% and 90%.

gence, and various engineering skills. Particularly noteworthy is the emphasis on digital and blue economy skills, which emerge as the most sought-after skills.

However, the survey brought to light significant challenges in recruitment, with nearly 80 percent of the surveyed organizations expressing difficulty in finding suitable candidates. Impediments include skillset misalignments, geographical constraints, and the absence of targeted educational programs. Non-competitive salary structures, sector-specific requisites, and limited interest in niche sectors further complicate the task of attracting and retaining highly skilled professionals.

Based on the survey responses, several noteworthy key points have emerged. For instance, there is clear evidence of a lack of female representation in technical positions (see Fig. 1). Additionally, the survey highlighted an average age range of 30 to 50 among technicians, underscoring that practical experience is the primary source of skills.

Organizations successfully circumventing talent acquisition challenges exhibit common strategies: they cultivate robust networks with local universities, invest significantly in specialized skills training, and maintain access to a diverse talent pool. They prioritize in-house knowledge building, continually adapt to technological advancements, and adopt a proactive stance towards ongoing training (see [6]).

IV. Courses development and pilots

Regarding the courses development, the current plan is to hold both academic and long-life (VET) courses. In the first case, the idea is to have courses with an European Qualifications Framework (EQF) level of 8 while for VET courses these are planned as levels 7 or 8. In both cases though, the consortium will provide 30 hours courses. For the academic courses, these 30 hours will be distributed along the academic semester in different lectures respecting the internal schedules of each participating university. For the VET courses, 2 models will be implemented: fieldwork training (summer school format) and one-week long training (theoretical and practical lessons combined).

Currently, the topics and modalities of delivery are being finalized considering the needs of the market identified in the market needs survey detailed in Section III. Similarly, the first pilots will occur in the summer in the form of fieldwork training/summer schools in Greece and Croatia.

In the following, a list of potential topics to be included in the courses depending on the final list of implemented courses, input from market stakeholders and students.

Regarding the courses related to blue skills the main topics include:

- underwater sensing: deployment, calibration, data acquisition and transmission
- processing and fusing optical and acoustic data for seabed mapping: seabed mapping techniques; methods and approaches for merging optical and acoustic data.
- integration of sensors and localization devices in seabed mapping operations: principles of georeferencing in seabed mapping; sensors and instruments for georeferencing; real-time georeferencing strategies.
- open-source low-cost underwater robotics: basic concepts and introduction to open-source underwater robotics; sensors and actuators for underwater robotics; programming and software development.
- Design of underwater and surface navigation and automation systems and practical applications of mission supervision & control and Guidance, Navigation and Control (GNC) for co-operative surveying and monitoring
- Autonomous operations of marine robots, in particular, Autonomous Surface Vehicles
- Data driven robot design and IT design for marine applications, Integration of IT skills for robot automation
- Advanced mission planning and simulation for cooperative autonomous marine vehicles
- Remotely Operated Vehicle (ROV) operation, piloting, maintenance, manipulation and applications
- Multidisciplinary applications for maritime robotics: biology, archeology, security, environmental monitoring
- Virtual Reality (VR) and wearables for diver-robot interactions
- Ocean literacy and blue skills for marine sciences
- Coastal geomorphological survey: vibracoring, analysis of sediments, electrical resistivity Transects (ERTs)

Regarding the courses related to digital skills the main topics include:

- underwater 3d photogrammetry: principles of digital photography; basic techniques and tools for UW image

processing; methodologies, tools and techniques for UW photogrammetry.

- Coastal and Shallow-water survey documentation techniques: UW topography, 3D aerial drone photogrammetry, satellite imaging and Geographic Information Systems (GIS)
- digital technologies to support surveying and documentation in scientific diving: overview of digital technologies in underwater surveying and documentation; digital tools for dive planning, navigation, data logging, and diver health monitoring; current trends and innovations in digital surveying.
- artificial intelligence techniques for target classification in underwater opto-acoustic imaging: basics of artificial intelligence in imaging analysis; data preprocessing and feature extraction; supervised and unsupervised learning approaches; performance metrics and evaluation.
- overview of machine learning and artificial intelligence (AI) / Applications of AI in marine robotics
- Advanced aquaculture management with intelligent predictive maintenance

Regarding the courses related to green skills the main topics include:

- diagnostic and archaeometry for underwater cultural heritage: overview of the main causes of damage to materials in seawater; stone materials and biological degradation: sampling phases, and preliminary investigations; analytical investigations for the study of materials: patina-substrate interaction.
- new techniques and materials for the preservation of underwater cultural heritage: overview of the main strategies adopted to preserve materials in seawater; eco-sustainable materials and products; tests and experiments, from the laboratory to the underwater site.
- analysis of microplastic presence in seawater: microplastics: definition and types; distribution of microplastics in seawater and sampling methods; spectroscopic analyses for the characterization of microplastics: FT-IR and Raman spectroscopy; microscopic analyses for the characterization of microplastics: optical microscopy and SEM-EDX analysis.
- environmental leadership (what is a leader, what type of leadership models exist, what kind of roles can someone take within environmental work/projects).
- climate emergency & climate action: main drivers and possible solutions, nature based solutions, mitigation, decarbonization, adaptation/resilience
- water pollution monitoring and assessment

Examples of technologies to be taught and used in the practical parts of the courses can be seen in Figures 2, 3 and 4.

Fig. 2: Autonomous Surface Vehicle H2Omni-X and Sensor Unit

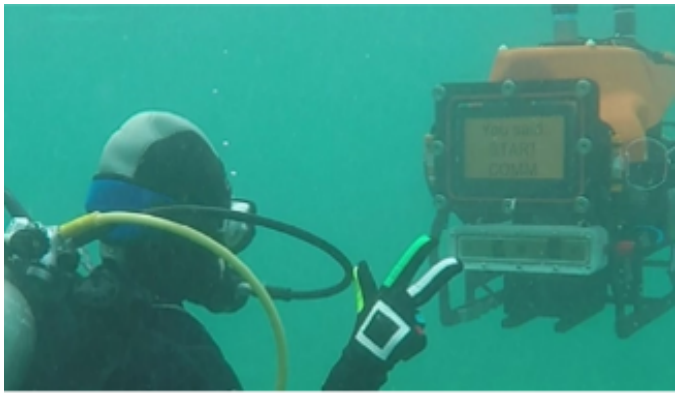

Fig. 3: Autonomous Underwater Vehicle BUDDY interacting with diver

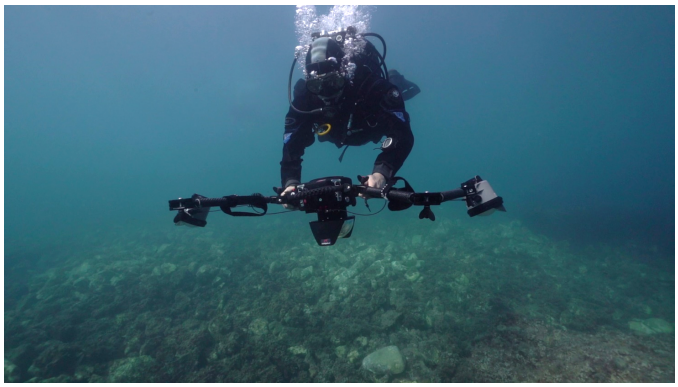

Fig. 4: Underwater photogrammetry

V. Conclusion

As shown in this paper, there is a need for training and reskilling in the Blue Economy sectors. The uBlueTec project aims to address that need by using an innovative triple transition training and skills development model (green, blue, digital skills). As first and cornerstone step of the project, a market survey was performed to understand the needs of companies and other stakeholders of the Blue Economy. The analysis of the survey is now informing the choice of courses among the wide list of topics provided by the very experienced and skillfull consortium. In the future, these courses will take place both in an academic format and life-long formats (e.g. summer

school) with the first pilots being planned for the Summer of 2024. An important aspect of the project is its sustainability and the focus at later stages will be on the development of a Hub where courses will be available for participants outside the consortium. More information is available on the project's website [4] and social media.

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