

ASSEMBLE



ASSOCIATION OF EUROPEAN MARINE BIOLOGICAL LABORATORIES EXPANDED

Acronym: ASSEMBLE Plus

Title: Association of European Marine Biological Laboratories Expanded

Grant Agreement: 730984

Deliverable 5.3

Report on Knowledge Transfer Activities to Engage Industry and Policy Stakeholders September 2022

Lead parties for Deliverable: AquaTT

Due date of deliverable: M60

Actual submission date: M60

All rights reserved

This document may not be copied, reproduced, or modified in whole or in part for any purpose without the written permission from the ASSEMBLE Plus Consortium. In addition to such written permission to copy, reproduce or modify this document in whole or part, an acknowledgement of



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984 (ASSEMBLE PLUS). This output reflects the views only of the author(s), and the European Commission cannot be held responsible for any use which may be made of the information contained therein.

the authors of the document and all applicable portions of the copyright must be clearly referenced.

GENERAL DATA

Acronym: **ASSEMBLE Plus**

Contract N°: **730984**

Start Date: **1st October 2017**

Duration: **60 months**

Deliverable number	5.3
Deliverable title	Report on Knowledge Transfer Activities to Engage Industry and Policy Stakeholders
Submission due date	September 2022
Actual submission date	November 2022
WP number & title	WP5: NA3 Engaging with user communities
WP Lead Beneficiary	CCMAR
Participants (names & institutions)	Avril Hanbidge (AquaTT)

Dissemination Type

Report	<input checked="" type="checkbox"/>
Websites, patent filling, etc.	<input type="checkbox"/>
Ethics	<input type="checkbox"/>
Open Research Data Pilot (ORDP)	<input type="checkbox"/>
Demonstrator	<input type="checkbox"/>
Other	<input type="checkbox"/>

Dissemination Level

Public	<input checked="" type="checkbox"/>
Confidential, only for members of the consortium (including the Commission Services)	<input type="checkbox"/>



Document properties

Author(s)	Avril Hanbidge (AquaTT)
Editor(s)	
Version	1.0

Abstract

The Report on Knowledge Transfer (KT) Activities to Engage Industry and Policy Stakeholders aims to describe the work carried out in relation to Knowledge Management and Transfer within the ASSEMBLE Plus project.

ASSEMBLE Plus adopted a Knowledge Management and Transfer process that was integrated into the project design, to ensure that all knowledge outputs (KOs) arising from the project, including scientific outputs, new methodologies, protocols and experimental approaches as well as new knowledge and strategies were managed. These KOs were captured, assessed and appropriately transferred where possible (taking privacy and Intellectual Property Rights (IPR) into consideration). This report provides an overview of the Knowledge Management and Transfer activities carried out by the partners since M15 - December 2018 as well as a description of the processes put in place to facilitate the targeted transfer of impactful KOs to target and end users once mature.

ASSEMBLE Plus has made significant contributions to the European marine biological research and industry landscape. It has tackled key challenges facing the industry including how researchers from academia and the private sector need high-quality access to sophisticated marine biological research infrastructures to conduct their research for the advancement of knowledge and technology, to inform policy and to contribute to blue growth.



Table of Contents

1. Summary.....	5
Objective:	5
Rationale:	5
Outcome:.....	5
2. Introduction.....	6
3. ASSEMBLE Plus Knowledge Management and Transfer	6
3.1 Knowledge Output Collection	7
3.2 Knowledge Output Analysis.....	9
3.3 Knowledge Output Transfer	10
4. Knowledge Transfer Activities and Impact.....	10
4.1 Knowledge Transfer Activities to Industry	11
4.2 Knowledge Transfer Activities to Policy	12
4.3 Knowledge Transfer Activities to Science.....	14
4.4 Knowledge Transfer Activities to Society	17
5. Conclusion	19
6. Appendix.....	21
ASSEMBLE Plus Knowledge Outputs: State of the Science Stories	21



1. Summary

Objective:

The Report on Knowledge Transfer (KT) Activities to Engage Industry and Policy Stakeholders aims to describe the work carried out in relation to Knowledge Management and Transfer within the framework of the ASSEMBLE Plus project from M15 - December 2018 until M60 - September 2022.

Rationale:

ASSEMBLE Plus adopted a Knowledge Management and Transfer process that was integrated into the project design, to ensure that all knowledge outputs (KOs) arising from the project, including scientific outputs, new methodologies, protocols and experimental approaches as well as new knowledge and strategies were managed. These KOs were captured, assessed and appropriately transferred where possible (taking privacy and Intellectual Property Rights (IPR) into consideration). The Knowledge Management and Transfer methodology that was employed throughout the project is described in detail in D2.4 ASSEMBLE Plus Dissemination and Exploitation Plan (DEP) V3 M60 Update (section 6). This report provides an overview of the Knowledge Management and Transfer activities carried out by the partners since M15 - December 2018 as well as a description of the processes put in place to facilitate the targeted transfer of impactful KOs to target and end users once mature.

Outcome:

AquaTT collected 10 KOs obtained from the KO collection rounds throughout the duration of the project. AquaTT with the Project Implementation Committee (PIC) carried out an assessment on collected KOs. These KOs covered new protocols for genetic manipulation and cryopreservation of marine organisms, genomic observatories, camera-based underwater surveying techniques, and novel experimental platforms. Knowledge Transfer Plans (KTPs) were developed for the KOs, to guide the KOs through the knowledge landscape to their eventual impact. ASSEMBLE Plus has made significant contributions to the European marine biological research and industry landscape. It has tackled key challenges facing the industry including how researchers from academia and the private sector need high-quality access to sophisticated marine biological research infrastructures to conduct their research for the advancement of knowledge and technology, to inform policy and to contribute to blue growth.



2. Introduction

Since its launch in September 2017, ASSEMBLE Plus has provided scientists from academia, industry and policy with access to over 30 marine biological stations and installations in 16 countries. Through specific initiatives such as the [Transnational Access Programme](#), [Networking Activities](#) and [Joint Research Activities \(JRAs\)](#), ASSEMBLE Plus stimulated European excellence in fundamental and applied research in marine biology and ecology. Research outputs supported by ASSEMBLE Plus have improved European knowledge and technology bases for applications in blue economy, policy and education.

The overall objective of WP5: NA3 Engaging with user communities was to facilitate effective knowledge exchange of ASSEMBLE Plus Knowledge Outputs (KOs) to all user communities; industry, policy, society and science, and so ensuring access to research outcomes which have taken end user needs into account. Specific objectives were to:

- Build strong RI capacity in value creation, impact and stakeholder engagement.
- Ensure effective consultation with key end users in order to strengthen the positioning of European marine biological stations as hot spots for excellent marine science.
- Carry out dedicated KT to relevant industry and policy stakeholders.
- Facilitate knowledge exchange (encouraging both formal and informal science education) amongst the marine biological scientific community with the aim to build capacity in individual scientists.

The specific objectives of D5.3 Report on KT Activities to Engage Industry and Policy Stakeholders, were to engage with the business and public policy sectors through multiple channels, carrying out dedicated KT of project KOs to the relevant industry and policy stakeholders.

To ensure measurable impacts in these sectors, an effective management and transfer of new knowledge to the relevant end users was required to increase the potential for uptake and application. ASSEMBLE Plus implemented a tried and tested, methodological Knowledge Management and Transfer process, to facilitate the collection and exploitation of all KOs arising from the project, including scientific outputs, new methodologies, protocols and experimental approaches as well as new knowledge and strategies. The methodology is described in detail in the ASSEMBLE Plus DEP V3 M60 Update (D2.4).

3. ASSEMBLE Plus Knowledge Management and Transfer

In its broad-based innovation strategy for the EU, the European Commission identified the importance of improving KT between public research institutions and third parties, including industry and civil society organisations, as one of ten key areas for action (http://ec.europa.eu/invest-in-research/pdf/download_en/knowledge_transfer_web.pdf). To be able to transfer knowledge, first, we need to manage knowledge. Knowledge Management is the process of creating, organising, and capturing knowledge to ensure its availability for future users. Targeted transfer activities can then take place to ensure that the knowledge is shared and distributed with key individuals whose uptake of the knowledge will result in research impact. ASSEMBLE Plus employs a proven Knowledge Management and Transfer methodology in order to effectively address this key aspect of facilitating



project impact. ASSEMBLE Plus knowledge and data management methodologies are described in more detail in both D2.4 ASSEMBLE Plus DEP V3 M60 Update and D4.3 ASSEMBLE Plus 3rd Data Management Plan (DMP).

KT is the overall process of moving knowledge between knowledge sources to targeted potential users of the knowledge. KT consists of a range of activities that aim to capture and transmit knowledge, skills and competence from those who generate them to those who will transform them into added value outcomes. It encompasses both commercial and non-commercial activities such as but not limited to research collaborations, consultancy, licensing, spin-off creation, researcher mobility, and publications. While financial benefits might be expected, KT helps ensure that research findings that might fulfil the wider needs of science, society, policy, and industry is adopted. The ultimate end benefit of successful KT is the application and influence of knowledge on targeted communities with greater impact (short and long term) across the triple helix of academia, industry and society (http://europa.eu/rapid/press-release_MEMO-07-127_en.htm?locale=en).

ASSEMBLE Plus has implemented the Knowledge Management and Transfer methodology originally developed in the FP7 MarineTT project (GA #244164), and further matured and applied within the H2020 COLUMBUS project (GA# 652690). This methodology has since been applied in many FP7 and Horizon 2020 funded projects. The methodology focuses on capturing all the project's KOs, defined as being a *'new/innovative unit of knowledge/key learning generated by or through research activity. They are not limited to de novo or pioneering discoveries and may also include new methodologies/processes, adaptations, insights, alternative applications of prior know-how/knowledge.'*¹ Traditionally, such knowledge might be referenced as a small part of a paper that is potentially not published until three to five years after the approach is pioneered in a research project. The KT process aims to accelerate this transfer of knowledge and to identify and prioritise which, if any, KOs have the potential for further development.

The Knowledge Management and Transfer methodology consists of the following three overall phases and is further described in detail below:

- a) Collect and Understand**
- b) Analyse and Validate**
- c) Transfer and Exploit**

3.1 Knowledge Output Collection

The aim of the 'Collect and Understand' phase was to collect all KOs produced within the project in an internal Knowledge Output Table (KOT) template. Capturing them in this way ensured quality control measures were performed and that the KO(s) could be clearly understood by others working in different disciplines, thus making them ready for analysis, the next step. This step also helps to clarify how the KO could be beneficial to different users by identifying potential applications, target and end

¹ www.columbusproject.eu



users and the eventual impact of the KOs. The ASSEMBLE Plus KO collection protocol is described in detail in D2.4 DEP V3 Update M60 (section 6.1).

In M15 – December 2018, AquaTT began collecting KOs from the ASSEMBLE Plus partners. Requests were sent to WP Leaders to identify KOs and for them to submit their KOs to AquaTT, by either filling out a KOT or by organising one-on-one calls between researchers and AquaTT, to discuss research carried out to date before filling in the KOT. From M40 – January 2021, AquaTT interviewed WP leaders, this was hoped to reduce the effort required by partners and for them to better understand what is required. During the collection interviews with the KO owners the potential users, applications and impacts of their KOs were also discussed. The KOs produced by the project are presented on the ASSEMBLE Plus website under the KT Platform to create the [State of the Science Stories](#).

The resulting 10 KOs are listed below, and screenshots with additional details are provided in the Appendix.

No.	Knowledge Outputs: What is ASSEMBLE Plus doing that is different?
1	Creation of a new genomics observatories: Ocean Sampling Day (OSD).
2	Creation of a new genomics observatory: Autonomous Reef Monitoring Structures - Marine Biodiversity Observation Network (ARMS-MBON).
3	Guidelines for standardisation of DNA metabarcoding.
4	Development of open access protocols: Cryomar Protocol Toolbox for cryopreservation.
5	Development of open access protocols for the genetic transformation of novel emerging metazoan, macroalgal and microalgal model organisms.
6	Development of open access protocols for the deployment of CRISPR/Cas9 system for novel emerging metazoan, macroalgal and microalgal model organisms.
7	Technical design specifications and guidelines for novel experimental platforms.
8	New survey techniques for diving: standard operating procedure guidelines for photogrammetry.
9	FAIR Data for Marine Biologists: Online Training Course.
10	Insights into the strategic operations of marine stations and the environments in which they operate.



3.2 Knowledge Output Analysis

In the Analyse and validate stage, the collected KOs are reviewed by AquaTT and the PIC to help clarify how the KOs could be beneficial and impactful by defining who the end users may be and what the eventual impact might be had following application of the KOs. Important aspects of analysis are to perform due diligence to confirm detailed profiling of Target and End Users to gain valuable data to inform successful KTPs ensuring optimisation of the KO’s impact if and when applied, as well as the prioritisation of potentially impactful KOs. AquaTT carried out the first assessment of the KOs collected. Each KO was reviewed and edited as necessary, including suggestions of additional potential end users, applications and impacts whilst ensuring each KO is adequately informative and comprehensive enough to understand the nature of it. Frequently, however, once end users and eventual impacts have been identified, it becomes apparent that the KO(s) being considered is(are) not yet sufficiently developed for transfer. For any KOs that may have been assessed as commercially/industrially exploitable, AquaTT informed the KO owner who is obliged to take responsibility of protecting the results according to GA Article 27 and subsequently exploiting the result complying with GA Article 28. The ASSEMBLE Plus Knowledge Management methodology also uses the Analysis stage to map the knowledge landscape in more detail, including any relevant authorities or influential parties – and their respective roles, responsibilities, and interests – who might serve as intermediaries in the transfer process, or allow further development of the KO to take further steps towards eventual transfer and impact. These actors are defined as target users, and the goal of the Analysis stage is the development of Knowledge Output Pathways (KOPs) that prescribe potential routes for guiding KOs through the knowledge landscape to their eventual impact, see Figure 1 below. A KOP is an analysed stepwise plan for achieving the identified eventual impact of any piece of knowledge, regardless of whether this impact is achievable short, medium, or long term (Figure 1). For more detailed information please refer to ASSEMBLE Plus D2.4 DEP V3 M60 Update (section 6.2).

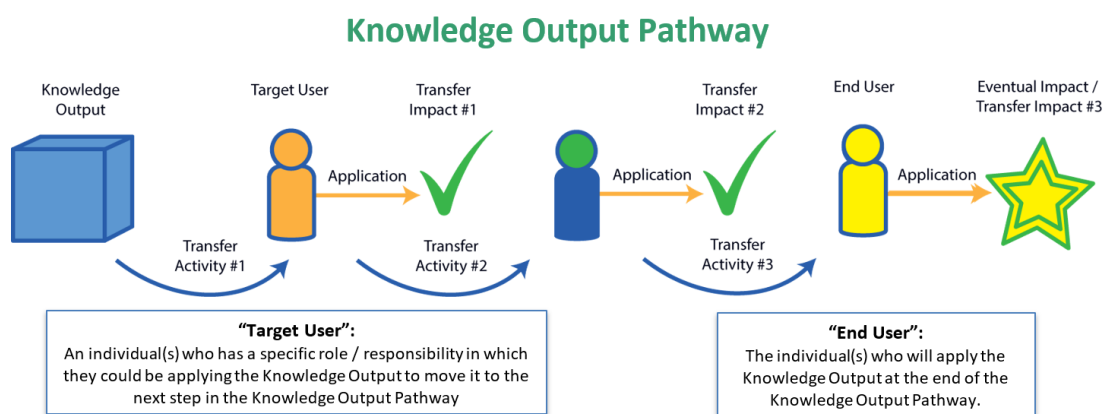


Figure 1. Knowledge Output Pathway

In M49 – 14 October 2021, AquaTT held a meeting with the WP leaders to outline their planned KT activities for their KOs. At this meeting, the KOs were reviewed, and progress updates were provided by the WP leaders, followed by in-depth discussions, and brainstorming on how to bring each KO further along their pathways with KT activities so that their expected impacts could be realised. Thorough identification of all possible target and end users and their related applications was carried



out. The identification of target users at this stage was critical to laying the groundwork for transfer and exploitation plans in the next stage.

3.3 Knowledge Output Transfer

As already defined section 3 above, KT is the term for the overall process of moving knowledge between knowledge sources to targeted potential users of knowledge. The objectives of this step are to elaborate on the information generated in step two, to develop plans for how to transfer the KOs to the identified target and end users, and to measure the success of any such transfer. For more detailed information please refer to ASSEMBLE Plus D2.4 DEP V3 M60 Update (section 6.3). Broader activities related to the transfer of knowledge generated by the ASSEMBLE Plus project have also taken place and are detailed in the following sections.

ASSEMBLE Plus utilises the Project Implementation Committee (PIC) to facilitate KT and enhance impact, the PIC is well placed to provide advice on alternative exploitation routes. Following the completion of the analysis exercise detailed in section 3.2, and once KOPs were developed for impactful KOs, draft KTPs could be designed. KTPs propose the activity, message, channel, timeline and respective resources required to complete the first or more steps of the KOPs. The impact of these activities, as well as general dissemination and communication, have been summarised in section 4.

From M49 – October 2021 to M60 – September 2022, AquaTT regularly contacted the WP leaders for progress updates on their KOs, the potential applications of these KOs, their pathways to impact and transfer plans. Transfer activities were recommended by AquaTT based on discussions at the WP leader meeting held in M49 (October 2021), where possible AquaTT and the PIC supported these activities. These transfer plans included more detailed profiles of the target users including, where possible, specific contacts and the individual partner within ASSEMBLE Plus best positioned to conduct the transfer. This step attempts to clearly describe how the impact of the ASSEMBLE Plus KOs is measured. Implementing an efficient KTP that is tailor-made to the needs and capacities of specific target and end users maximises the chance of successful transfer resulting in uptake and application. The KTPs include proposed mediums and channels for transfer as well as indicators that can be used to measure impact. The suggested responsible partners support the implementation of the KTPs with KO owners taking the lead.

The [State of the Science Stories](#) (Appendix) on the ASSEMBLE Plus KT Platform was updated accordingly and promoted through the final [ASSEMBLE Plus Newsletter Issue 5](#) and the final project [press release announcing the end of the project](#) in M60 – September 2022.

4. Knowledge Transfer Activities and Impact

KT encompasses both commercial and non-commercial activities such as research collaborations, consultancy, licensing, spinoff/spinout creation, researcher mobility and publications. KT aims to support mutually beneficial collaborations between universities, businesses and the public sector. It is about the transfer of tangible and intellectual property, expertise, learning and skills between the research community and the non-academic community. The benefits of KT – in other words, the exploitation of research - go beyond simple financial return. The benefit also lies in a number of other,



less tangible, benefits for research institutions, for industry and for society as a whole, such as helping research institutions focus their research on the wider needs of society and industry ([http://europa.eu/rapid/press-release MEMO-07-127_en.htm](http://europa.eu/rapid/press-release_MEMO-07-127_en.htm)).

4.1 Knowledge Transfer Activities to Industry

Results and outputs important for the marine industry sector (marine biotechnology, aquaculture and related blue growth industries) have been presented and showcased by ASSEMBLE Plus partners at international conferences, exhibitions and various other events to facilitate awareness and reach potential new markets.

Examples of science to industry activities carried out by partners include:

- ASSEMBLE Plus outputs are transferred to industry through partner participation at industry-related events, through existing industry connections within the partnership i.e., partners who are members of panels, advisory boards and working groups with industry experts and through other European funded projects.
- JRA2 Cryobanking marine organisms lead partner UPV/EHU organised the brokerage event ‘New Standardisation of Cryopreservation Protocols for Marine Organisms’ as part of the ASSEMBLE Plus Conference 2021 online in M40 - 28 January 2021. Key stakeholders related to cryobiology were invited. A major driver to host the brokerage event was the release of the ASSEMBLE Plus repository of methodologies for the cryogenic preservation of marine organisms. Launched in M34 - July 2020, the [Cryomar Protocol Toolbox](#) (D8.2) represents a collaborative effort from researchers across Europe from several marine stations. The event was attended by 31 participants and provided a platform for researchers, companies and equipment providers to meet and discuss cryopreservation of marine organisms, while also showcasing new tools and resources, and exchanging ideas. Some outcomes of the event are:
 - Marine aquaria aim to use the technology for biodiversity conservation and knowledge was exchanged.
 - We learnt the technology is already being used to cryopreserve plankton larvae for aquaculture feed and there was interest in expanding this to other organisms.
 - A start-up company producing caviar from mussels are interested in taking up the technology.
- JRA2 Cryobanking marine organisms have also produced the public deliverable [D8.2 - Cryomar Protocol Toolbox available online here](#). Future plans include ensuring this technology reaches all the relevant stakeholders, that they are aware the technology exists and its limitations and perhaps we will identify new applications and therefore users!
- As part of the ASSEMBLE Plus Conference: Marine biological research at the frontier held in M40 - January 2021 and in M57 – June 2022, through technology demonstrations ASSEMBLE Plus partners showcased their research areas and facilities, while also demonstrating their equipment/technology platforms and the services they can offer. Short videos also gave insight into a number of European marine stations and research infrastructures (RIs) available to industry that would enable them to increase their efficiency and facilitate innovation. B2B matchmaking events were also made available to facilitate networking with industry stakeholders.
- For JRA4 Developing Instrumentation, while there are no formal plans to commercialise the database (which is accessible to ASSEMBLE Plus and EMBRC members), there have been



discussions about how the database could be exploited in a wider context. For example, it could be accessed externally via a “pay wall” or published freely and form of consultancy service could be provided based on this information. It is recognised that the IP of such a platform could be complicated, unless information is provided on a voluntary and open basis. The main output from JRA4 is the database of instrument reviews, targeting marine stations as the end users. JRA4 will produce the public deliverable D10.1 Technical design specifications and guidelines for experimental systems in M60 – September 2022.

- From JRA5 Scientific Diving, the oil and gas industry are using the same stereophotogrammetry software as is being used by the ASSEMBLE Plus researchers. They will have adapted the software to their own use-cases, which is where their IP lies. They have also developed their own methodologies using unmanned underwater robots. While the focus of ASSEMBLE Plus is on standardising the approach for scientific teams, commercial opportunities will be sought for the outputs of this research, as well as the skills that are developed in the course of doing the work, particularly as the commercial licenses for the software and the advanced levels of computing power required are costly to resource. JRA5 has produced the public deliverable - [D11.1 Standard operating procedure guidelines for photogrammetry](#).

4.2 Knowledge Transfer Activities to Policy

The purpose of KT to policy is to transfer the knowledge to strengthen the positioning of European marine biological stations as hot spots for excellent marine science. By sharing this knowledge, ASSEMBLE Plus has the aim to engage with policy-forming and policy-implementing actors (JPI Oceans, Marine Board) and elected representatives in governments appropriate to the several marine station sites within ASSEMBLE Plus.

Science to policy activities carried out by partners include:

- ASSEMBLE Plus outputs are transferred to policy through participation at policy-related events, through existing policy connections within the partnership i.e., partners who are members of panels, advisory boards and working groups with policymakers and through other European funded projects.
 - Within JRA1 there are two genomic observation networks: Ocean Sampling Day (OSD) and Autonomous Reef Monitoring Structures (ARMS-MBON).
 - JRA1 leader HCMR has conducted a preliminary analysis on the DNA metabarcoding of the OSD 16S rRNA data, to gain insights into the value of the data. These analysis results (species identifications) and the raw sequence data are published, to be shared for exploration with experts around the world. The OSD 2018 and 2019 sampling, environmental, and raw sequence data are published as a metadata record via VLIZ’s Integrated Marine Information System (IMIS); the OSD 2014 data have long been published on PANGAEA. Species identifications obtained from all three years of OSD will also shortly be submitted to biodiversity archives (OBIS, GBIF). 1) [OSD metadata record for 2014 in PANGAEA](#); 2) [OSD metadata record for 2018 in IMIS](#) and 3) [OSD metadata record for 2019 in IMIS](#). The datasets and metadata are also available via the [OSD GitHub Repository](#) which also provides the data in machine-accessible formats, ensuring the data is in compliance with H2020’s Open Research Data Pilot, following the principles of FAIR (Findable, Interoperable, Accessible and Reusable).



- OSD will continue as [EMO BON \(European Marine Omics Biodiversity Observation Network\)](#) and is the main activity of the EMBRC-ERIC. EMO BON has been incorporated as part of the Global Youth Biodiversity Network and it will soon be officially endorsed as a project into the [UN Decade Programme OBON \(Ocean Biomolecular Observing Network\)](#). During RP3, Nicolas Pade (EMBRC-ERIC) presented EMO BON at the 2022 UN Ocean Conference in Lisbon in M57 – June 2022.
 - [ARMS-MBON](#) has developed a number of outputs including a Handbook, Molecular Protocols, Guides to Access and Benefit Sharing (ABS) and data Management Plan. ARMS partners have published many papers based on ARMS MBON and many partners are prepared to continue ARMS after ASSEMBLE Plus ends in September 2022 and are willing to fund the sequencing etc. Its impact within policy is evident through its uptake with the Swedish National Environmental Agency (SwAM) co-financing the 2020 sampling event as well as public tenders for hard bottom monitoring to include ARMS. In Denmark, ARMS has been added to the annual monitoring protocols of hard rocky reefs. Its impact in industry is evident from SMEs such environmental consultancies adding the DNA-based monitoring to their profiles.
- The recently funded Horizon Europe project, MARCO-BOLO (MARine COastal BiODiversity Long-term Observations) is also coordinated by EMBRC, and its partnership also comprises of ASSEMBLE Plus partners including VLIZ, UGOT, AWI, SZN, MBA, AquaTT/ERINN and SU. This project will start in December 2022 and aims to structure and strengthen European coastal and marine biodiversity observation capabilities, linking them to global efforts to understand and restore ocean health, hence ensuring that outputs respond to explicit stakeholder needs from policy, planning and industry. MARCO-BOLO will establish and engage with a Community of Practice (CoP) to determine end user needs with the aim of optimising marine data flows, knowledge uptake and therefore improving governance based on biodiversity observations. The project partnership will leverage its international activities such as Marine Biodiversity Observation Network (MBON), Global Ocean Observing System (GOOS), Ocean Biodiversity Information System (OBIS) and participation in the UN Ocean Decade Programmes (Marine Life 2030, Ocean Biomolecular Observing Network (OBON), Ocean data and Information System (ODIS), Ocean Practices for the Decade) to align the MARCO-BOLO work programme to global CoP, ensuring European participation and leadership in global biodiversity monitoring and global science.
- Nicolas Pade, ASSEMBLE Plus Coordinator (EMBRC-ERIC) is the current chair of the [EuroGOOS Biological Observation Working Group \(BIOGW\)](#) and is also sitting on the [EOOS Operational Committee](#). Partners of ASSEMBLE Plus and MARCO-BOLO are also members of the BIOGW including Andreja Ramšak (NIB), Costas Frangoulis (HCMR), Daniele Iudicone (SZN), Susan Evans (NOC) and Klas Ove Moeller (Hereon).
- [The eDNA project](#) is an ambitious two-year project using cutting edge environmental DNA (eDNA) to understand the richness of biodiversity of UNESCO's marine World Heritage sites. It will help understanding of global trends and inform ongoing efforts to protect marine ecosystems and ensure future generations continue to enjoy the services they provide. The ASSEMBLE Plus Scientific Coordinator EMBRC (Nicolas Pade) and partner VLIZ (Pascal Hablutzel) are both represented as members of the [Advisory Board of UNESCO's](#)



[eDNA project](#). This Board brings together some of the world's leading science and experts in molecular ecology, eDNA, bioinformatics, fish metabarcoding and ocean science. One of the Board's main roles is decision-making support as the sampling results will help governments to adapt decision-making as marine biodiversity evolves in a warming climate.

- As part of the ASSEMBLE Plus Conference: Marine biological research at the frontier held in M40 - January 2021 and in M57 – June 2022, B2B matchmaking events were made available to facilitate networking with policy stakeholders.
- Networking Activity 4 (NA4) Long-term sustainability lead partner UPV/EHU organised the workshop '[Business models and Smart Sustainability of Marine Stations](#)' as part of the ASSEMBLE Plus Conference 2022 online in M57 - June 2022. ASSEMBLE Plus focused on the effective integration and efficient complementarities of the marine stations to provide research services and attract new users. The main results were presented in this science to policy transfer event with Inmaculada Figueroa, the Vice Deputy Director General for the Internationalization of Science & Innovation at Ministry of Science and Innovation in Spain in attendance. The Ministry of Science and Innovation of Spain oversees the Spanish marine RIs. Eleni Hatziyanni from the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE) was also in attendance. DG MARE has developed the new thematic platform, the Smart Specialisation for Sustainable Blue Economy Strategy. Marine stations are often located in peripheral maritime regions, where industrial development can be particularly low and also at a distance from the central decision-making districts. It was pivotal for them to join forces as part of ASSEMBLE Plus to improve the sustainability of the marine stations and create new prospects for their strategic development. With the fisheries industry diminishing, it will be ever more important for R&D to improve the blue bioeconomy and liaise with regional governments. EMBRC have analysed the marine stations to establish that more than 23 regions have exploited the Smart Specialisation for Sustainable Blue Economy Strategy. The aim of this exercise is to align the funding streams with these 23 regions, increasing their connectivity. The Platform will bring all stakeholders together; this is its scope and will be operational by end of year. Brokerage events and further events/opportunities will be organised to align our activities to not try to speak the same language but to find common pathways of cooperation and to align the way we bring the research activity to the market.
- Claire Jolly, Head of Innovation Policies for Space and Oceans Unit at the OECD was invited to attend the ASSEMBLE Plus Final General Assembly in M60 – September 2022 to learn about the project's final outputs. Claire and her team are working to provide evidence-based information to improve the research and innovation policy mix for sustainable ocean management. The OECD Directorate for Science, Technology and Innovation (STI) works on the ocean economy and published findings of the OECD's 2016 foresight report '[The Ocean Economy in 2030](#)'. Building on these activities, a new major STI ocean economy foresight activity is starting, entitled The Ocean Economy in 2045. ASSEMBLE Plus partner SZN is also a member of the [STI Ocean Economy Steering Group](#).

4.3 Knowledge Transfer Activities to Science

ASSEMBLE Plus results important for the scientific community have been published in high impact peer-reviewed scientific journals. The peer-reviewed scientific articles have been made available through either free online repositories ('green' open access) or open access journals ('gold' open



access), and links to all publications have also been included by VLIZ on the ASSEMBLE Plus project website under [Publications](#) and the associated datasets under the [ASSEMBLE Plus Data Collection](#).

- Through the ASSEMBLE Plus Transnational Access (TNA) Programme over 500 scientific research projects and scientists from around the world were supported. The TNA Programme enabled mutually beneficial research collaborations, researcher mobility and publications between universities, businesses and the public sector. The Programme not only introduced scientists to new facilities but also included the transfer of expertise, learning and skills by offering training, and networking opportunities between the research communities (including hundreds of early career researchers) as well as to non-academic communities. The TNA Programme also enabled new strands of research by funding pilot projects. TNA user experiences are showcased on the [Success Stories webpage](#) of the ASSEMBLE Plus project website and within the [ASSEMBLE Plus Newsletter Issues](#), demonstrating some of the impacts the TNA Programme has had.
- The project results have also been presented as oral and poster presentations at major international meetings and conferences. Examples of participation of ASSEMBLE Plus partners at events to transfer science results of ASSEMBLE Plus to science stakeholders through oral/poster presentations, workshops and/or distribution of project material include:
 - EU/Latin America Caribbean Meeting in Brussels, Belgium. 14 March 2018. SU presented ASSEMBLE Plus.
 - International Symposium of Marine Science in Vigo, Spain. 20-22 June 2018: UPV/EHU presented two posters.
 - International Symposium in Eilat, Israel. 11-13 February 2019. HUJI presented ASSEMBLE Plus.
 - Cryopreservation of Marine Genetic Resources: from the Ocean to your Marine Station Workshop. 26-27 June 2019. Participation by SAMS.
 - European Phycological Conference in Zagreb, Croatia. 29 August 2019. SZN presented Grants & funding opportunities of EU research infrastructure access programmes.
 - ASSEMBLE Plus Conference 2021: Marine biological research at the frontier, organised by CCMAR was held online in M40 – 18-29 January 2021. The conference had several aims:
 - To present the offerings and services available from ASSEMBLE Plus partners to potential users.
 - To showcase the projects and scientific achievements of hosted ASSEMBLE Plus users.
 - To collect feedback from stakeholders on improving the services offered and extending its reach to the scientific community, especially with industry partners.
 - To promote the project and the services offered by its partners.

The conference was widely promoted amongst the scientific community via social media and press releases, leading to high levels of attendance with over 400 attendees (574 registered participants) from 50 countries. Most attendees (95%) came from academia within Europe (85%), and participation at individual sessions ranged from 30-80 people per session. ASSEMBLE Plus partners showcased their research areas and facilities, while also demonstrating their equipment/technology platforms and the services they offer. Short videos gave insight into a number of European marine



stations and research infrastructures (RIs) available to the academic community that would enable them to increase their efficiency and facilitate innovation. The project was honoured to have six keynote speakers Rudolf Amman (Max-Planck-Institut für Marine Mikrobiologie, Germany), Chris Bowler (Institut de Biologie de l'École Normale Supérieure, France), Colin Brownlee (Marine Biological Association, and School of ocean and Earth Sciences, University of Southampton, UK), Ester Serrão (CCMAR, Portugal), Maria Ina Arnone (SZN, Italy) and Vincent Laudet (Okinawa Institute of Science and Technology, Japan). CCMAR and other partners followed up activities with stakeholders to home in on the wealth of information and experience shared throughout the conference. Feedback received informed the design of the final ASSEMBLE Plus Conference. The programme from this conference can be found [here](#) and videos from the sessions are available on [EMBRC's YouTube channel](#). See [D5.2 Stakeholder consultation report](#) for more details.

- ASSEMBLE Plus Conference 2022: Marine biological research at the frontier, organised by CCMAR was held online in M57 – 13-24 June 2022. The final conference had a packed programme that included an enjoyable mix of presentations of the latest research by ASSEMBLE Plus partners and users, Q&A discussions, short videos giving insight into European marine stations and RIs, service and technology demonstrations and B2B matchmaking events with industry as well as workshops. The project was honoured to have three keynote speakers, Detlev Arendt (European Molecular Biology Laboratory (EMBL), Germany); Melody Clark (British Antarctic Survey, UK) and Matthew Sullivan (Ohio State University, USA). The conference had an audience of international marine biology stakeholders from industry, research, policy and potential investors as well as members of the public with an interest in marine biological research. The event was widely promoted amongst the scientific community via social media and press releases, leading to high levels of attendance with over 400 attendees (246 registered) from 50 countries, with daily participation ranging from 100-150 people. Conference organisers were delighted to receive positive feedback from those who attended, as well as gratitude for the conference recording from those who were either unable to attend or missed parts due to different time zones around the world! The [programme from this conference is available on the event webpage](#) and videos from the sessions will soon be made available on the [EMBRC's YouTube channel](#).
- From JRA3 Functional Genomics, it is possible to study many different gene functions and the bioactive properties of some of their gene products. Protocols for genetic transformation and generation of knockouts are produced. This project will continue after ASSEMBLE Plus. So far, we have achieved good results for both macroalgae and diatoms. For now, we are concentrating on targeting academia through scientific publications but in the future, there is the possibility to use these protocols on other organisms. JRA3 has published many papers covering the protocols and produced two public deliverables - [D9.1: Protocols for genetic transformation of model organisms](#) and [D9.2: Protocols for the deployment of CRISPRCas9 system](#).
- ASSEMBLE Plus has transferred open access knowledge, methods, guidelines and tools related to marine biological research to students and professionals with the aim to build community capacity, enabling confident, organised, and influential staff members in RIs to demonstrate value creation from the research they generate and their marine stations.



- As part of [D5.1 Report on RI capacity in value creation, impact and engagement](#), a questionnaire was developed to identify key skills that were required by the participating RIs. Skill gaps identified by the questionnaire indicated there was a need to build capacity in IP; KT; Media skills; Networking; Policy development; and Outreach and stakeholder engagement. AquaTT highlighted the best guidelines, tools and resources for these skills to partners as part of D5.1. As KT requires an individual to participate in several elements of communication, dissemination and exploitation, AquaTT provided the webinar ‘KT Online Training for the ASSEMBLE Plus Community’ in M60 on 22 September 2022. The webinar covered topics - how to identify KOs within your research and how to analyse KOs and map their pathway to impact.
- Knowledge exchange and training activities were part of [D5.4 Knowledge exchange among scientific community for enhanced training of actual and prospective RI users](#), particularly to early career researchers. These activities had an important dual role of promoting RI platforms and services to prospective new users, while also providing fundamental training for researchers. Examples of training courses provided by partners include:
 - Zebrafish tools for the screening of osteogenic compounds led by João Paulo Gavaia (CCMAR) took place in M22 on 15-17 July 2019 in Faro, Portugal with eight participants who rated the course 5.0/5.0.
 - Liquid chromatography and Mass Spectrometry methods in Marine Sciences led by José Paulo Silva (CCMAR) took place in M25 on 28-30 October 2019 in Faro, Portugal with 20 participants who rated the course 4.4/5.0.
 - Practical course on meta-omics data processing analysis and organization: bioinformatics tools to mine and share the data led by Maria Luisa Chiusano (SZN) took place in M29 on 3 - 7 February 2020 in Naples, Italy with 23 participants who rated the course 4.5/5.0.
 - The Evolution of Enzymes and Metabolic Pathways: analysis, understanding and implications for biotechnology led by Immacolata Castellano (SZN) took place in M57 on 28-30 June 2022 in Naples, Italy with 15 participants who rated the course 4.1/5.0.
 - The courses ‘Cryopreservation of dinoflagellates’ led by Estefania Paredes (UPV/EHU) and ‘Identification of larval fishes as a tool for systematics, ecology, and population dynamics’ led by Roi Holzman (IUI) did not get to take place due to COVID-19 restrictions.

4.4 Knowledge Transfer Activities to Society

ASSEMBLE Plus has focussed on developing and communicating a suite of outreach activities and products to ensure engagement with European citizens. Several project partners have undertaken outreach activities, making use of the supports developed within WP2 and WP5 NA3 to provide dynamic outreach products e.g., project factsheet, newsletters and graphics.

ASSEMBLE Plus has also developed numerous project communication materials to facilitate KT to all target and end users. These materials include:



- [ASSEMBLE Plus website](#), which provides resource material on all aspects of the project (partnership, objectives, expected outcomes etc.). The dedicated ASSEMBLE Plus website plays multiple roles including a repository for public deliverables and outcomes; a link for partners to the internal collaborative platform Basecamp; a repository for publications and their underlying datasets. The website also makes appropriate use of Web 2.0 tools such social networking site, Twitter along with video and photo sharing sites (e.g., YouTube, Vimeo, etc.). These tools are linked to and integrated into the ASSEMBLE Plus project website throughout the course of the project. AquaTT with support from VLIZ and EMBRC-ERIC have actively maintained the ASSEMBLE Plus project website carrying out general dissemination of ASSEMBLE Plus results, news, events and progress. Also, the events webpage includes relevant events both for ASSEMBLE Plus partners to target for dissemination as well as to identify other related initiatives which would be useful to interact with. ASSEMBLE Plus has presented a high level of marine biology-related news items published on the project website, in the project newsletter and project social media channels. Please see also [D2.5 Project Website and Video](#).
- ASSEMBLE Plus factsheet describes the project, its challenges, objectives and expected results. It is available from the project website and can be viewed under [Portfolio of Project Promotional Materials](#).
- ASSEMBLE Plus project video was designed and developed to introduce the project, its objectives and to raise awareness of its activities including the TNA Programme. The video was launched in M12 – September 2018. It is available for viewing by the general public on the [ASSEMBLE Plus project website](#); AquaTT’s accounts of video-sharing websites [Vimeo](#) and [YouTube](#). The video has been widely disseminated through ASSEMBLE Plus and partners’ social media to stakeholders and the general public to raise awareness, attract interest and promote new potential markets. Partners were encouraged to share the video with their wider networks and the partnership was also encouraged to use the video in their existing and future international outreach activities. Both ASSEMBLE Plus Conferences in 2021 and 2022 were kicked-off by broadcasting the video to an audience of over 400 attendees from 50 countries. As of September 2022, the video has 512 views on Vimeo and 59 views on YouTube. More information can be found in [D2.5 Project Website and Video](#).
- ASSEMBLE Plus social media. ASSEMBLE Plus communicates and transfers knowledge through a dedicated project Twitter account that has been actively maintained by AquaTT. Twitter and LinkedIn have been used to promote ASSEMBLE Plus activities and results as well as connecting and interacting with other marine biology-related projects, relevant academic, industry, policy and regulatory bodies. All ASSEMBLE Plus partners were encouraged to regularly share their news and results through these channels. As of September 2022, the ASSEMBLE Plus Twitter account ([@ASSEMBLE Plus](#)) has 997 followers and 1,307 tweets and so has a large target audience.
- ASSEMBLE Plus project newsletter was a tool for promoting the project, its objectives, partners, progress and results to a wide audience including all partners, stakeholders and possible end-users. Since September 2017, AquaTT developed, published and distributed five newsletters (M8 – May 2018, M12 – September 2018, M27 – December 2019, M43 – April 2021 and the fifth and final issue in M60 – September 2022). These newsletters were distributed to project partners, stakeholder database contacts, existing media channels and any other interested individuals who had subscribed using the ‘Click here to subscribe’ button on the project website, ensuring



compliance to GDPR. The newsletters highlighted project results and included project reports, news and events. The newsletters use appropriate non-technical language suitable for a general audience and are widely disseminated, including to the ASSEMBLE Plus social media channels and the ASSEMBLE Plus stakeholder database which as of September 2022 has 413 subscribers. All ASSEMBLE Plus newsletter issues can be accessed on the ASSEMBLE Plus website under [Newsletters](#).

- ASSEMBLE Plus Access Provider Spotlight is a series of articles profiling the ASSEMBLE Plus Access Providers and their facilities across the 16 partner countries. The series is showcased on the ASSEMBLE Plus website and social media channels. Its aim was to aid TNA Programme applicants in choosing an Access Provider based on their location, ecosystem access and facilities. The series can be accessed on the ASSEMBLE Plus website under [News](#) as well as [Our Access Providers](#).
- ASSEMBLE Plus outreach coffee table book, 'History of Marine Biological Stations: contributions to Science and Social Challenges' (D6.1) was produced in M27 – December 2019 by partner UPV/EHU to highlight the function and value of marine biological stations, retrospectively evaluating their scientific and socioeconomic impact, both in their tangible and intangible aspects and identifying the future roles of marine stations in addressing new challenges and opportunities. The history of the stations will be presented in this promotional book to illustrate their relevance to citizens, academics, researchers and policy makers alike. The book is available for download from the ASSEMBLE Plus website [D6.1 Outreach book history of marine biological stations](#).
- AquaTT and other partners have also produced [24 press releases](#), along with several [news items and promotional articles](#) at regular intervals and distributed via a range of dissemination channels such as the project website, social media channels, stakeholder database (total of 56 mailings throughout the project) and the project newsletters. D2.4 DEP V3 M60 Update includes instructions and clarifications for partners to be able to maximise the communication and dissemination of the ASSEMBLE Plus project and its results also after the project ends. It gives instructions on the appropriate methods and times to use the different resources. Project partners have contributed content to the project website, social media channels and newsletters, with many providing original photographs of field activities and facilities.

5. Conclusion

ASSEMBLE Plus has tackled key challenges facing the marine biological industry including how researchers from academia and the private sector need high-quality access to sophisticated marine biological research infrastructures to conduct their research for the advancement of knowledge and technology, to inform policy and to contribute to blue growth. As both the world population and marine biological industry continue to expand, it is vital to develop new, innovative and eco-friendly solutions to ensure sustainability.

With the goal of stimulating European excellence in fundamental and applied research in marine biology and ecology, since its initiation in 2017, ASSEMBLE Plus has improved our knowledge and technology bases for blue economy, policy, and education purposes. The project integrated over 30 marine biological stations and installations from across Europe. Key achievements from ASSEMBLE Plus include:



- Supporting over 500 international researchers from 46 different countries with their projects, while also enabling new strands of research by funding pilot projects.
- Introducing scientists to new facilities as well as offering training, networking and countless collaboration opportunities for hundreds of early career scientists.
- Creating two new initiatives for genomics observatories: [Ocean Sampling Day \(OSD\)](#) and [Autonomous Reef Monitoring Structures - Marine Biodiversity Observation Network \(ARMS-MBON\)](#).
- Developing open access protocols: [Cryomar Protocol Toolbox](#) for cryopreservation, and for the [genetic transformation of novel emerging metazoan, macroalgal and microalgal model organisms](#) and the [deployment of CRISPR/Cas9 system for novel emerging metazoan, macroalgal and microalgal model organisms](#).
- [Guidelines for standardisation of DNA metabarcoding](#).
- Technical design specifications and guidelines for novel experimental platforms, [deliverable coming soon](#).
- New survey techniques for diving: [standard operating procedure guidelines for photogrammetry](#).
- Raising awareness among the scientific community of the importance of managing data under the FAIR and open access principles including the building of data workflows, catalogues and virtual environments: [FAIR Data for Marine Biologists](#) training course.
- Providing significant insight into the strategic operations of marine stations and the environments in which they operate. This included strengthening and developing the marine stations' provision of services, building strong links between them and demonstrating their worth: [Business Plan for Marine Biological Stations](#).

Legacy and sustainability of ASSEMBLE Plus:

Post ASSEMBLE Plus, the genomic observatories are continuing as the [European Marine Omics Biodiversity Observation Network \(EMO BON\)](#), an EMBRC project aiming to enhance the European contribution to global genomic observation efforts. OSD will continue in another project, [AtlantEco as All Atlantic Sampling Day](#).

Both ASSEMBLE and ASSEMBLE Plus have contributed significantly to the establishment, services, management and protocols of EMBRC. Half of ASSEMBLE Plus access providers are part of the EMBRC network meaning services will be maintained, there will be unlimited access and the legacy of ASSEMBLE Plus will continue through EMBRC. The platforms and protocols developed during ASSEMBLE Plus can be accessed through the [EMBRC's Service Catalogue](#).

EMBRC enables researchers to better understand the ocean's biodiversity by facilitating access to marine organisms and their ecosystems, while providing the necessary services, facilities and other resources to support innovative research. Services are provided by more than 70 sites in ten member countries: Belgium, France, Greece, Israel, Italy, Norway, Portugal, Spain, Sweden and the United Kingdom. [Read more about how to access EMBRC services](#) or [watch the ABCs of using EMBRC video](#).

In addition to providing various services, EMBRC contributes to European and international projects. Diverse in scope and country involvement, these projects aim to enhance EMBRC activities and/or services, strengthen collaboration with similar European organisations, structure the research



community and provide services to support research. You can learn more about the projects EMBRC are involved in by visiting the [EMBRC Projects page](#).

6. Appendix

ASSEMBLE Plus Knowledge Outputs: State of the Science Stories

State-of-the-Science Stories: Genomics Observatories

What is a Genomics Observatory?



A Genomic Observatory as an ecosystem and/or site subject to long-term scientific research, including (but not limited to) the sustained study of genomic biodiversity from single-celled microbes to multicellular organisms.

In ASSEMBLE Plus' Genomics Observatories joint research activity, coordinated genomics observations of planktonic and benthic communities will be performed and optimised. Building on the long-term investment, infrastructure, expertise, and traditions of more than 20 ASSEMBLE Plus marine stations, ASSEMBLE Plus will also produce a roadmap for our marine genomic observatories, to optimise their outputs and to ensure their longevity.

What is a ASSEMBLE Plus doing that is different?

1. ASSEMBLE Plus is coordinating the Ocean Sampling Day

The Ocean Sampling Day (OSD) is a world-wide sampling programme: one day every year hundreds of scientists and citizens collect water samples from the ocean in a coordinated and controlled manner. These samples are sequenced at HCMR in Greece, to extract the DNA of whatever is in the water, telling us what was living at that sampling site the time. Each yearly OSD dataset can tell us the composition of the ocean as sampled from hundreds of sites across the world. Taken together with the in-situ measurements of the physical (temperature, etc) and chemical (salinity, etc) conditions, the OSD data over the years can tell us how climate change is affecting life in the oceans.

OSD challenges are genomics observatory challenges. OSD takes place at every summer solstice (21st June). Each year, new stations register, and contribute to that year's OSD event and to the subsequent OSD events. In each station, environmental and genomic data are produced following standardised sampling and experimental procedures for reproducibility and comparability. Samples are centralised for further processing (biobanking, high molecular weight DNA extraction, DNA metabarcoding of prokaryotic and eukaryotic microbial communities) to avoid biases between individual laboratories.

OSD in 2018 and 2019 delivered high-quality genomic DNA for 65 stations, which are being amplicon* sequenced and will soon be jointly submitted to shotgun** metagenomics sequencing. All data and metadata, genomics and environmental, will be made publicly available via the ASSEMBLE Plus [data collection](#). OSD events are a great exercise in acquainting the community with the production and value of high-quality Findable, Accessible, Interoperable and Reusable (FAIR) data, which until now has been more of a wish than of a practice.

2. ASSEMBLE Plus is participating in the ARMS project

The Autonomous Reef Monitoring Structures (ARMS) are units made up of eight connected and stacked plates. A unit is placed on the sea floor, and over a period of time it gets colonised by whatever is living there. Because of their three-dimensional structure, mimicking the complexity of hard bottom marine substrates, they attract encrusting species (corals, algae, etc.) and motile organisms (crustaceans, mollusks, polychaetes, etc.). The key innovation of the ARMS is their ability to sample marine communities over precisely the same area and in the exact same manner providing a standardised and quantifiable measure of biodiversity over time and location. The ARMS-MBON project (Marine Biodiversity Observation Network for genetic monitoring of hard-bottom communities) which has a focus on Europe and the polar regions, is part of ASSEMBLE Plus.

Unlike the water column that is sampled by OSD, the nature of benthic habitats presents a huge diversity which it makes it difficult – if not impossible – to standardise the sampling methods to allow a comparison of the biodiversities from different sites and from different times. This is where the ARMS come in: as passive collectors that can be deployed in any type of benthic habitat, they sample the marine benthic fauna in a standardised and repeatable way.

ARMS deployment has been taking place in two phases. The exploratory phase in 2018 aimed to train our practitioners, benchmark the sampling and analysis methods, and decide on deployment periods. This phase has completed and the data are in process of analysis, and will be archived in our ASSEMBLE Plus [data collection](#). The second phase began in 2019, during which specific scientific questions were addressed, for example we focussed on determining the capacity of the ARMS to detect non-indigenous species (NIS) around ports. ARMS units have been deployed in 19 sampling areas at ASSEMBLE Plus sites in European coastal waters and Antarctica, in triplicates whenever possible. Once brought up, each ARMS plate is treated separately (high-resolution photographs are taken, and DNA metabarcoding of eukaryotic communities are produced). ARMS can be used for a broad range of questions including long-term ecological research, monitoring, and inventory (LTER).



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

3. ASSEMBLE Plus is working on barcoding reference databases.

Finally, ASSEMBLE Plus aims to enrich the local DNA barcoding reference databases (Guillou et al., 2013; Glöckner et al., 2017; Herbert et al., 2003), so that DNA metabarcoding (Ruppert et al., 2019) captures taxonomically well-annotated biodiversity data. Indeed, DNA metabarcoding is a high-throughput, effective, and relatively cheap method for assessing biodiversity. Despite that, a high percentage of biodiversity that could be captured by DNA metabarcoding method remains unknown, mainly because of the relatively poor reference databases that exist for DNA barcoding. ASSEMBLE Plus' work is working towards improving this shortcoming.

What Next?

- Monthly OSD sampling will be undertaken (2020) at some of ASSEMBLE Plus' stations
- The ARMS data will be uploaded to Genomic Observatories Meta-Database (GEOME)
- All OSD and ARMS data and metadata will be added to the ASSEMBLE Plus [data collection](#) in 2020

Potential Impact

At the international level, we are at present *far* from being able to produce long-term genomic data that can allow for a deep understanding of biodiversity dynamics in terms of structure and function across geographical areas and ecosystem types. Such data are simply not produced. ASSEMBLE Plus is building the elements of an infrastructure that will allow the production of such data, making it FAIR and publicly available. OSD and ARMS are such examples of this, involving broader international collaborations. ASSEMBLE Plus is now in the process of moving from the test level to the operational level. Once completed, ASSEMBLE Plus will deliver a roadmap for long-term observations of marine ecosystems by combining standardised methods for genomics and environmental data, and by integrating new technologies and data types.

Other outputs include standards for databases and operating procedures, there have also been learning outcomes e.g., how to get scientists and data to talk to each other! But also how to set up both infrastructures is a lesson learnt.

* "Amplicon" works by amplifying the strands of DNA in the sample, and extracts marker genes to identify the population/community composition of the sample.

** "Shotgun" involves breaking the genome collected from the sample into a collection of small DNA fragments that are sequenced (i.e. the ATCG patterns are read and digitised) individually. A computer program looks for overlaps in the DNA sequences and uses them to place the individual fragments in their correct order to reconstitute the genome. Thus, shotgun metagenomics is to comprehensively sample all genes in all organisms present in a given complex sample.

References

Davies, N., Meyer, C., Gilbert, J.A., et al. (2014) A call for an international network of genomic observatories (GOs). *GigaScience*, 1(1): 5.

Davies, N., Field, D., Amaral-Zettler, L., et al. (2014) The founding charter of the Genomic Observatories Network. *GigaScience*, 3(1): 2.

Guillou, L., Bachar, D., Audic, S., et al. (2013) The Protist Ribosomal Reference database (PR2): a catalog of unicellular eukaryote small sub-unit rRNA sequences with curated taxonomy. *Nucleic Acids Res.* 41(D1): 597-804.

Glöckner, F.O., Yilmaz, P., Quast, C., et al. (2017) 25 years of serving the community with ribosomal RNA gene reference databases and tools. *J Biotechnol.*, 10(261): 169-176.

Hebert, P.D., Cywinska, A. and Ball, S.L. (2003) Biological identifications through DNA barcodes. *Proc R Soc Lond B Biol Sci.*, 270: 313–21.

Ransome, E., Geller, J.B., Timmers, M., et al. (2017) The importance of standardization for biodiversity comparisons: A case study using autonomous reef monitoring structures (ARMS) and metabarcoding to measure cryptic diversity on Mo'orea coral reefs, French Polynesia. *PLOS ONE* 12(4): e017508.

Ruppert, K. M., Kline, R. J., and Rahman, M. S. (2019) Past, present, and future perspectives of environmental DNA (eDNA) metabarcoding: a systematic review in methods, monitoring, and applications of global eDNA. *Global Ecol. Conser.* 17:e00547. doi: 10.1016/j.gecco.2019.e00547

Wilkinson, M.D., Dumontier M., Aalbersberg I.J., et al. (2016) The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3: 160018.

Scientific resources

The datasets published with the OSD data can be found in the ASSEMBLE Plus datasets collection: OSD2018 and OSD2019, and you can also see previous OSD14 metadata record in [Pangea](#). All three records in IMIS can be found [on this page](#).

The publications from JRA1 that are in the ASSEMBLE Plus collection can be found [on this page](#).



State-of-the-Science Stories: Cryobanking Marine Organisms

What is Cryobanking?



Cryobanking is the process of cooling and storing cells, tissues, or organs at very low or freezing temperatures to preserve them for future use. Cryobanking allows one to use the preserved material for a much longer period of time, allowing for a broader range of R&D and industrial uses.

ASSEMBLE Plus is working on the design of cryopreservation protocols of various marine genetic and biological resources (e.g. genetically-modified metazoans, macroalgae and microorganisms) for bio-banking. These organisms are strategically important resources for academia and industry (e.g. with bio-actives for food, feed, pharma and cosmetics), but cryobanking protocols for them are not yet sufficient or do not exist. We are also exploring processes to extend the reproduction window of commercial species.

What is ASSEMBLE Plus doing that is different?

Aquaculture

ASSEMBLE Plus is working on the developing the protocols that will allow the cryopreservation of sea urchins and mussels. Sea urchins only reproduce for four to six months of the year, and this is inefficient for research purposes! While it is possible to force their reproduction by tricking them into believing that it is spring (hence creating a stock of out-of-season reproducers), this is expensive. Cryopreservation of the sperm, embryos, or larvae in a biobank is a cheaper and better alternative, allowing one to work with sea urchins all year around. Cryopreservation has also proven to be an incredibly useful technique for the land animal breeding sector, and it can equally be useful for sea urchin seed production.

As mussels also reproduce only twice a year (in spring and autumn), this is inefficient for research and for the aquaculture industry. It is believed that cryopreservation here can also offer an opportunity for extending the mussel window, but until now this had not been achieved. The research team at the Universidade de Vigo obtained this year, for the first time, seed from cryopreserved mussel larvae (*M. galloprovincialis*). These were then grown to juvenile stage and then put through the ropes in a marine environment to reach maturation. A proof of concept that cryopreservation of mussel larvae can be used to improve market seasonality was thus achieved! A protocol for mussel spawning was developed and the results are published. As IFREMER has already done the same for oysters (*C. gigas*), it is quite clear that cryopreservation of molluscs has a great potential in the aquaculture industry.

Biodiversity

One of the most interesting applications of cryopreservation and biobanking is its role in preserving genetic biodiversity, and specifically in the preservation of the genetic material of endangered species. CCMAR is working on with the cryopreservation of the Portuguese oyster (*C. angulata*) and of species of biomedical interest such as different zebrafish strains.

This biodiversity preservation is important and useful for culture collections and research facilities. Roscoff are investigating the cryopreservation of species of macroalgae, e.g. *Laminaria* sp. and *Prophyra* sp. SAMS have developed a method for cryopreserving gametophytes of the brown seaweed, *Saccharina latissima*, and this has resulted in a paper (Visch et al., 2019). NIOZ has successfully developed a cryopreservation protocol for hypersaline microbial mats (a multi-layered sheet of different microorganisms of a few centimetres thick that grow in moist areas), which can now be preserved at -150 °C and can be grown again for 120 days!

In total, ASSEMBLE Plus has developed cryopreservation approaches for over 200 algal species (micro and macroalgae), thanks to the combined efforts on standardising and training among several institutions: SAMS, Roscoff Marine Station (SU), MBA, UPV-EHU, ECIMAT-Uvigo). Cryopreserved samples can now be shipped using one-use dry shippers between institutions in a very simple and comfortable manner.

Products and outputs

- ASSEMBLE Plus deliverable, [Depository of current methodology and discussion forum porta](#): Outlining the state-of-the-art methodology and accumulated knowledge as a starting point for the development of JRA2's research efforts in cryobiology applied to the marine environment.

What next?

- The CCMAR team has been working on the development of improved cryopreservation protocols for *Chamelea gallina* and *Crassostrea angula* sperm and larvae.
- UPV are working on sperm cryopreservation for the thicklip grey mullet (*Chelod labrosus*), which are used as sentinels of environmental health in pollution monitoring campaigns on the Basque coast.
- Roscoff, SAMS, MBA and ECIMAT are working on the identification of recalcitrant microalgae species (species that are difficult to cryopreserve). Experiments for benthic-filter feeder, amphioxus, are scheduled for next spawning season to test a number of cryopreservation techniques on embryos, and then to evaluate using markers and/or sequencing techniques.



Potential Impact

Research conducted at the University of Vigo on sea urchin embryo cryopreservation was patented in 2015, and as yet no-one has shown an interest in buying the patent. Interest in land-based seed production is renewed, and it is clear that cryobiology can be used as an out-of-season tool for seed storage.

In general molluscs and other marine invertebrate fisheries and aquaculture companies rely on the intake of seed from the ocean. This is the case of mussels in Spain where seed is extracted from the rocky shores of selected locations. Cryopreservation can mitigate the impact that collecting seed from the natural environment can have, and can allow for the species to be grown year-round.

Many traditional fisheries such as of clams have been approaching culturing in a sustainable way, producing seed inland that is later transferred to the beach to increase natural production and ensure annual collection rates without over-exploitation of the resources. They are always restocking. This approach means that they are better prepared for the future market, and are mitigating risks related to climate change.

This approach can be also useful for sea urchins, with worldwide decline of stocks and many EU fisheries reporting overfishing. However, attempts to grow sea urchins either inland or on-shore have not been successful. Cryopreservation of seed would make it possible to seed the ocean in known areas, to re-stock natural populations and to allow a healthy production-extraction balance. This provides a cheaper, more efficient, and functional way to allow the continued fishing of sea urchins.

Cryopreservation has been use in land animals husbandry for decades now and has boosted the industry in many directions. It is being used for animal conservation efforts and repopulation. In the marine field, cryobanking is still under development. Thanks to Assemble Plus, a critical mass of knowledge now exists, allowing us to make a leap in development. We aim to make researchers aware of the multiple applications that exist right now and that will exist in the near future.

As part of the ASSEMBLE Plus Conference 2021 - Marine biological research at the frontier, JRA2 organised a Cryopreservation Brokerage Event with the aim of providing a platform for researchers, companies and equipment providers to meet, talk, and exchange ideas around the cryopreservation of marine organisms. Key stakeholders related to cryobiology were invited. During the event, the [Cryomar Protocol Toolbox](#) was presented alongside new tools and resources that are available. Some outcomes of the event are:

- Marine aquaria aim to use the technology for biodiversity conservation and knowledge was exchanged.
- We learnt the technology is already being used to cryopreserve plankton larvae for aquaculture feed and there was interest in expanding this to other organisms.
- A startup company producing caviar from mussels are interested in taking up the technology.

JRA2 have also produced [Deliverable 8.2 - Cryomar Protocol Toolbox available online here](#). Future plans include ensuring this technology reaches all the relevant stakeholders, that they are aware the technology exists and its limitations and perhaps we will identify new applications and therefore users!

References

- Diogo, P., Martins, G., Quinzixo, I., Nogueira, R., Gavaia, P.J. and Cabrita, E. (2018) Electric ultrafreezer (- 150 °C) as an alternative for zebrafish sperm cryopreservation and storage. *Fish Physiol. Biochem.*, 44(6): 1443-1455
- Diogo, P., Martins, G., Eufrásio, A., Silva, T., Cabrita, E. and Gavaia, P. (2019) Selection criteria of zebrafish male donors for sperm cryopreservation. *Zebrafish*, 16(2): 182-196
- Heres, P., Rodriguez-Riveiro, R., Troncoso, J. and Paredes, E. (2019) Toxicity tests of cryoprotecting agents for *Mytilus galloprovincialis* (Lamarck, 1819) early developmental stages. *Cryobiology*, 86: 40-46
- Paredes, E. and Bellas, J. (2019) The Use of Cryopreserved Biological Material for Water Quality Assessment. *Frontiers in Marine Science*, doi: 10.3389/fmars.2019.00454
[https://patentscope.wipo.int/search/en/detail.jsf?docId=ES154529708&recNum=50&docAn=201400536&queryString=FP:\(Universidade%20de%20Vigo\)&maxRec=140](https://patentscope.wipo.int/search/en/detail.jsf?docId=ES154529708&recNum=50&docAn=201400536&queryString=FP:(Universidade%20de%20Vigo)&maxRec=140)
- Riesco, M.F., Félix, F., Matias, D., Joaquim, S., Suquet, M. and Cabrita, E. (2019) Comparative study on cellular and molecular responses in oyster sperm revealed different susceptibilities to cryopreservation. *Aquaculture*, 498: 223-229
- Rodriguez-Riveiro, R., Heres, P., Troncoso, J. and Paredes, E. (2019) Long term survival of cryopreserved mussel larvae (*Mytilus galloprovincialis*). *Cryobiology*, 512, doi: 10.1016/j.aquaculture.2019.734326
- Visch, W., Rad-Menéndez, C., Nylund, G.M., Pavia, H., Ryan, M.J. and Day, J. (2019) Underpinning the development of seaweed biotechnology: Cryopreservation of brown algae (*Saccharina latissima*) gametophyte. *Biopreservation and Biobanking*, 17(5), doi: 10.1089/bio.2018.0147

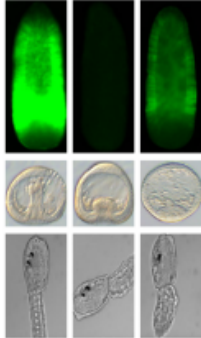
Scientific resources

Some datasets linked to the JRA2 protocols can be found in the ASSEMBLE Plus datasets collection, from [this page](#). The publications related to these datasets are linked in these records. All the publications from JRA2 that are in the ASSEMBLE Plus collection can be found on [this page](#).



State-of-the-Science Stories: Functional Genomics

What is a Functional Genomics?



Functional genomics is a field of molecular biology that attempts to describe gene (and protein) functions and interactions.

These days it is quite easy to obtain whole genome or transcriptome data and much research focusses on this. The study of the specific functions of single genes is also a vital part of understanding genetics, but it is difficult to do compared genome-wide studies. This is therefore the focus of JRA3's work: single-gene function studies using up-to-date approaches such as CRISPR-Cas9. ASSEMBLE Plus will adapt and implement protocols to generate genetically modified metazoans, macroalgae and microorganisms, all of which represent strategically important resources for academia and some of them also for industry (e.g. bio-actives for food, feed, pharma and cosmetics).

What is ASSEMBLE Plus doing that is different?

CRISPR is a simple yet powerful tool that is used for editing genomes. It allows researchers to easily alter DNA sequences and modify gene function. Its many potential applications include correcting genetic defects, studying gene functions, treating and preventing the spread of diseases, and improving crops through transgenesis.

For the purpose of our ASSEMBLE Plus work, CRISPR can be used to knock out a gene, to then study the effect of its loss and therefore its function. The protocols for doing this have been fully established for the sea urchin (both *Paracentrotus lividus* and *Strongylocentrotus purpuratus*) and three other marine metazoans (the cnidarian *Clytia hemisphaerica* and the ascidians *Ciona intestinalis*, and *Phallusia mammillata*). However, in amphioxus (the cephalochordate *Branchiostoma lanceolatum*), even if the first results are promising now that the JRA3 team has shown that CRISPR-Cas9 can mutate genes in these cephalochordate embryos, not all cells mutate in the first generation and so more work is necessary to obtain complete mutant lineages. Other approaches such as insertional transgenesis worked in all the four animal models, sea urchins, ascidians, *Clytia* and amphioxus, and also with different ratios of insertion, from complete mutants to mosaic animals.

All the required material is ready to explore the brown algae *Ectocarpus*. Work is underway on the diatom *Phaeodactylum tricornutum*, with some gene knockout strains identified.

What next?

- Work will continue on macroalgae including *Ectocarpus* and kelps, especially *Saccharina latissima*).
- Work will continue on microorganisms including (the diatoms *Seminavis*, *Cylindrotheca* and *Pseudo-nitzschia multistriata*, the pioeukaryotes *Ostreococcus* sp, *Bathycoccus* and *Micromonas*, the cyanobacteria *Synechococcus* and the bacteria *Kordia algicida*).

Potential Impact

Once ASSEMBLE Plus gains a better understanding of the functional genomics of the species covered, it will be possible to study many different gene functions, and the bioactive properties of some of their gene products.

Protocols for genetic transformation and generation of knockouts will be produced. This project will continue after ASSEMBLE Plus. So far we have achieved good results for both macroalgae and diatoms. For now we are concentrating on targeting academia but in the future there is the possibility to use these protocols on other organisms. JRA3 has published many papers covering the protocols and two deliverables - [D9.1: Protocols for genetic transformation of model organisms](#) and [D9.2: Protocols for the deployment of CRISPR-Cas9 system](#).



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730984. This output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

State-of-the-Science Stories: Developing Instrumentation

Scientific Instrumentation



ASSEMBLE Plus is working on developing instrumentation that is used at marine research stations. Our activities are currently focused on developing a database featuring reviews on the aquarium systems and equipment being used by the ASSEMBLE Plus research institutions. We are also interested in encouraging crossover and knowledge sharing between research institutions.

What is ASSEMBLE Plus doing that is different?

Database of Instrument Reviews

Purchasing aquarium systems and equipment is a rare occurrence within an organisation, but they are vital equipment for R&D. However, here is currently no reference material available to consult when updating technology or equipment within laboratories! ASSEMBLE Plus will fill this gap by creating a database with reliable advice, based on real experience with the equipment. The database is currently at a prototype stage and the "Research Aquarium Infrastructure" on-line database was launched this summer. It features technical information about the categorised pieces of equipment, including cost, location and process.

Knowledge Sharing in Technology Developments

Innovations are often developed in isolation. ASSEMBLE Plus is encouraging individuals from research institutions to collaborate and share ideas as they develop new or adapt existing technologies. Seven "technical challenges" task forces are charged with developing improvements to, and harmonising designs of, selected categories of experimental systems: tide simulation, CO₂ control, pH control, LEDs, multiplex systems, flow chambers and turbulence.

The achievements thus far are as follows:

- Station Biologique de Roscoff (France) and the Universidade de Vigo (Spain) have collaborated over the development of a tidal simulator. Together, they have developed three prototypes and have managed to upscale to 500 litres. The prototypes include a sensor for ultrasound levels and a programmable interface, they can regulate pH, and they can allow experimental replication with a multiple tank system. The Hebrew University of Jerusalem (Israel) improved the pH regulation and the implementation of in-situ PAM (pulse amplitude modulated fluorometer) analysis in their Red Sea simulator.
- Sorbonne Université's Oceanographic Observatory of Banyuls-sur-Mer (France) adjusted their microplate experimental system to be easier to implement and get a better fit to natural spectra.
- The University of Gothenburg (Sweden) tested their systems for automating manipulation of carbonate chemistry.
- Flanders Marine Institute (Belgium) saw improvements made to their ocean acidification experimental facilities (larger tanks and smaller mesocosms) and sediment micro-profiling system. CCMAR implemented ocean acidification facilities. The Marine Biological Association (UK) have improved their mesocosm facility.
- Stazione Zoologica Anton Dohrn (Italy) updated their seagrass culture (light, pH).

What next?

- In terms of the database, the focus is on adding and curating the submitted data. After all, if the database is not maintained, there will be no audience to satisfy. Data entry will continue until the end of 2019. After that, the data will be analysed to produce a technical design manual and best practice recommendations (for completion by October 2020).
- When developing new instrumentation or identifying new applications for existing instrumentation, it opens an opportunity to patent the ideas. As understanding of the patent process is limited within the scientific community – and there is a feeling that technology transfer offices are driven by numbers of patents submitted over the best interest of the knowledge owners – it would be beneficial to host a training course for ASSEMBLE Plus partners on intellectual property and patents.
- The University of Helsinki will be developing a mesocosm facility, which will be active from 2020.

Potential Impact

While there are no formal plans to commercialise the database (which will be accessible to ASSEMBLE Plus and EMBRC members), there have been discussions about how the database could be exploited in a wider context. For example, it could be accessed externally via a "pay wall" or published freely and form of consultancy service could be provided based on this information. It is recognised that the intellectual property of such a platform could be complicated, unless information is provided on a voluntary and open basis.

The main output from JRA4 is the database of instrument reviews, targeting marine stations.



State-of-the-Science Stories: Scientific Diving

Stereophotogrammetry



ASSEMBLE Plus' Scientific Diving team are currently focused on developing their capabilities in stereophotogrammetry, otherwise known as "structure from motion" or "3D photogrammetry".

Stereophotogrammetry is a methodology that uses normal imagery (photos, videos, micrographs), to generate three-dimensional point clouds that stitch the images together to build a 3D image.

The beauty of the technique is that it only needs images from a single camera, and there is no need to control set distances or angles. This makes it much easier for the diver holding the camera! Such images can be used to make retrospective, reliable measurements even down to the millimetre scale (if the images are of high enough resolution); it is as if the subject is sitting your own lab! Because the models are constructed mostly from close-up imagery, the water effectively disappears. In low-visibility environments, large-scale targets become totally visible, and things that could never be observed with the human eye can be seen. More importantly, the amount of information that can be gathered in one dive (or voyage using a drone or remotely operated underwater vehicle) is significantly more than studying the object directly underwater. It is, therefore, time and resource efficient.

Stereophotogrammetry has many applications: habitat mapping, measuring the volume of coral, estimating carbonate production rates, calculating erosion or biofouling rates on underwater structures. It could also be used to capture a moment in time for a time-series or historical database; if, for example, subsequent years of volumetric changes of environments such as ice shelves were required. Those benefitting from this technique could be geologists, surveyors, archaeologists and intertidal biologists.

What is ASSEMBLE Plus doing that is different?

Standardising Stereophotogrammetry Methodologies

With computer-based work, it is important to be confident of the accuracy and reliability of the results. The ASSEMBLE Plus researchers are working in multiple teams, operating from the Arctic to the Mediterranean, to interrogate the results that their respective models are generating to test their accuracy and precision. One of our goals is to develop a standard methodology that can be applied by different teams, such that the same results are always produced no matter which team is using them or which project they are working on.

What next?

- It is hoped that the underwater observation network that has been created will further expand, and will demonstrate the value of diver-based, sub-tidal physico-chemical observation (e.g. sea-surface temperature).
- The next workshop will take place in December 2019 at the Hellenic Centre for Marine Research in Heraklion (Greece).

Potential Impact

The oil and gas industry are using the same stereophotogrammetry software as used by the ASSEMBLE Plus researchers. They will have adapted the software to their own use-cases, which is where their intellectual property lies. They have also developed their own methodologies using unmanned underwater robots. While the focus of ASSEMBLE Plus is on standardising the approach for scientific teams, commercial opportunities will be sought for the outputs of this research, as well as the skills that are developed in the course of doing the work, particularly as the commercial licenses for the software and the advanced levels of computing power required are costly to resource.

