EMBRC
EUROPEAN
MARINE
BIOLOGICAL
RESOURCE
CENTRE

EMBRC Science strategy 2020-23

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Introduction

The European Marine Biological Resource Centre (EMBRC) is a 'distributed research infrastructure' (RI) that enables research on marine organisms and ecosystems, promoting their sustainable exploration and use. Headquartered in Paris, we have nine member countries (Belgium, France, Greece, Israel, Italy, Norway, Portugal, Spain, UK).

EMBRC's core activity is to support research requiring access to marine ecosystems and their biodiversity. It offers access to the analytical platforms and complex experimental systems necessary to reproduce environmental conditions and understand their effects on marine organisms.

Our services can be accessed both remotely and on-site and are available to users from public and private sectors. Our on-site users can benefit from the expertise of technicians working at the 45+ EMBRC sites, as well as proximity to the local marine environment and their organism(s).

Training is an important component of our activities. It is primarily offered through Marine Training, a web-based platform developed by EMBRC to offer an overview of current marine and maritime education opportunities. The platform provides a supporting framework to foster new training initiatives and exchange best practices. It aims to train the next generation of 'blue workers' and re-train the current generation, while providing answers to trainees and trainers alike. EMBRC also works to develop new tools for training, ensuring that they can provide the tailored, on-demand courses that users expect today. Finally, we support staff exchanges to continually develop individual competencies.

EMBRC works in a dynamic, constantly changing environment. In order to continue to support cutting-edge marine biological research, it must regularly evaluate and adapt its scientific strategy and service offer.

The 2020-2023 EMBRC Science Strategy outlines new services and updates to existing ones to ensure that the organisation can continue to serve the research community with the tools necessary to support innovative research.

Biodiversity monitoring, characterisation, and taxonomy

Strategic drivers

Ecological and biodiversity research are gaining in importance in the context of climate change, calls for the sustainable use of the marine environment and its biological resources, as well as the need for greater understanding of marine ecosystems.

These topics are important factors in recent policy agendas and initiatives, including the European Commission's 'blue economy' agenda, the Marine Strategy Framework Directive (MSFD), the Healthy Seas and Oceans mission of Horizon Europe, and the United Nations Decade of Ocean Science for Sustainable Development (2021-2030).

EMBRC should support research in topics such as marine meta-genomics, marine microbiomes, ecosystem structure and functioning, biodiversity, and biodiversity response to stressors. For this purpose, EMBRC must adopt the appropriate tools and observational databases. Ecological research relies heavily on quantitative, long-term data to determine trends and patterns, and therefore, EMBRC needs to provide novel types of observational data (ie, genomics data) to complement the traditional Long Term Ecological Research (LTER) time series data already collected in many marine stations.

Taxonomic identification is integral part of marine biological research. It provides users with assurance that they have obtained the appropriate organism.

Species lists in monitoring programmes need to be correct, and species' names in publications must be validated. Unfortunately, taxonomy has been underfunded for decades, resulting in a scarcity of taxonomic experts in the marine biological community. Nonetheless, taxonomy has experienced a renaissance as of late. This is thanks, in part, to the importance of biodiversity in areas such as ecosystem functioning, climate change, blue bio-resources, and to new tools to study biodiversity, including genomics tools.

Marine ecosystems are highly diverse and harbour a vast array of organisms which have adapted to their specific environment. However, only a tiny proportion of these organisms has been identified, and the unique biomolecules and metabolites which have evolved from these organisms are also largely unexplored.

EMBRC 'Operators' (ie the EMBRC partners providing services in the member countries) have developed unique platforms for marine-based biodiscovery. These platforms start at the organism level and go up to isolated compounds or molecules through biomass-based isolation strategies or molecular approaches. To harvest and harness molecules and compounds found in marine ecosystems, there is an urgent to develop a framework for biodiscovery, upgrade equipment, and boost capabilities.

Strategic recommendations

Improving support for environmental and ecological research means focusing on improving biodiversity observation at EMBRC sites and deploying new technology and tools.

Many EMBRC Operators already run sites for long-term environmental and biodiversity observation. Additional components can be integrated into existing activities, and new technology and data incorporated to ensure relevancy. The following developments are recommended:

- **Genomic Observatories:** EMBRC should initiate the first coordinated, permanent Genomics Observatory network along the European coasts. This will ensure the harmonised generation of baseline genomic biodiversity data from single-celled microbes to multicellular organisms. Genomics Observatories (GOs) will collect data from the pelagic zone, soft sediments and hard substrates to provide a holistic view of the marine environment. Protocols should be developed from the operational LTER sites as well as global initiatives such as 'Ocean Sampling Day' (OSD) and 'Autonomous Reef Monitoring Structures' (ARMS), currently trialled in the EMBRC-coordinated, Horizon 2020-funded ASSEMBLE Plus programme. Learn more: https://www.embrc.eu/collaborative-projects/assemble-plus-association-european-marine-biological-laboratories-expanded

  Sequencing protocols need to be harmonised for the aforementioned sampling domains to ensure data comparability and reproducibility. Data formats should conform to global standards to ensure their widest possible use, and resulting data should be made freely available. A working group should develop operational and costing rules, shared protocols for sampling and data polishing, and data standards. A memorandum of undersatnding (MoU) should be established among participating EMBRC facilities to agree on this shared, long-term commitment as well as its duration. The initiative will involve LifeWatch-ERIC for the purpose of using its analytical tools to explore the resulting data.

- **Taxonomic services:** EMBRC possesses excellent taxonomic competencies in a wide variety of organism groups. The Operators with such expertise should develop on-demand services, using both genetic approaches and classical taxonomic identification, for the user community. At the same time, gaps in existing expertise and competent experts should be identified and potentially incorporated into EMBRC. Interaction and collaboration should be explored with the Distributed System of Scientific Collections (DiSSCo) for taxonomic training.

- **Bioprospecting:** Ecosystem-based exploration and mapping need to be linked to bioprospecting. EMBRC is in a prime position to coordinate such an initiative. Organisations such as EU-OPENSCREEN are dedicated to the screening of molecules of economic interest, but they mainly target isolated secondary metabolites and other isolated molecules. They lack the expertise in the marine domain to cover the initial parts of the blue biodiscovery pipeline.

  EMBRC needs to strengthen its bioprospecting capacity in collaboration with EU-OPENSCREEN, and ensure that its Operators benefit from this exchange in order to maximise efficiency, minimise duplication, and improve effectiveness. The collaboration should encompass issues related to science, business, ethics and more.

Domestication of marine species

Strategic drivers

Increasing numbers of marine species are relevant in the context of the European Commission's blue economy agenda because they are sources of food, feed, and other valuable products (eg, biomaterials, medicines, antibiotics, food additives, secondary compounds). In addition, marine species constitute important models in research fields such as evolutionary developmental biology (evo-devo), neurology, ethology, biogenesis and biophysics. Marine species often exhibit straightforward biological solutions to daunting problems in engineering and robotics, and they serve as living biosensors in various early-warning systems.

Mass harvesting of many of these organisms in the wild is generally not an option for various reasons: they may be rare, difficult to locate (eg due to size), and occur seasonally or unpredictably, or harvesting may have potentially deleterious effects for the surrounding ecosystem. Moreover, wild-type organisms or their strains often grow slowly or yield products of interest only in small quantities; they may also only grow together with other organisms or in poorly understood conditions. Harvesting these organisms in an ecological and economically sustainable way requires growing them under controlled conditions, often away from the sea. In fact, most of the anticipated growth in seafood consumption with a rising world population will need to come from aquaculture. This is because harvesting from natural populations will reach or exceed limits for sustainable exploitation. The EMBRC community could play a pivotal role in developing and supporting innovations in aquaculture breeding technology. In this way, EMBRC would contribute to future food security and biosecurity. These innovations could carry over to other marine-derived products including nutraceuticals, cosmetics and drugs.

Adapting marine organisms to user needs (eg simple breeding in captivity, growth in high density, high expression of desired traits) often requires selective breeding for specific traits, and thus understanding and controlling organisms' life cycles. In addition, identifying the genetic mechanisms which underpin changes in quantitative or qualitative traits often requires the characterisation of the organism's genomes, transcriptomes and metabolomes. All this information enables targeted genetic improvements through selective breeding as well as advanced genome editing technologies and other post-genomics approaches (see chapter on post-genomic tools).

A possible complication affecting culturing in captivity arises from the fact that many species live in symbiosis, at times in consortia involving multiple species. Away from their symbionts, they fail to act the way in which they are supposed to act. Moreover, it is often not the target organisms, but their inconspicuous symbionts that produce the substances of interest. Nonetheless, selective breeding and genome editing are applicable in the case of symbioses of several species. It is simply necessary to clarify roles so that the appropriate partners are identified for the purpose of selective breeding and genome editing.

Another challenge for the development of marine organisms for the blue bio-economy is the adaption of small-scale, 'proof-of-concept' production to large-scale industrial production. Many projects struggle in this step, failing to achieve technological readiness.

Strategic recommendations

EMBRC already has the capacity to support 'domestication' of non-model organisms locally (at its participating marine stations); however, this is not explicitly offered as a service at all stations, or made clear in the service catalogue. Nonetheless, it is unrealistic that each EMBRC partner has all the services in place for any type of organism. For EMBRC to be relevant for the various scientific user communities as well as for blue biotech start-ups, SMEs and industries, it needs to take into the account the following recommendations:

i. Culture collections should carefully be expanded to incorporate existing and emergent model organisms, which are not currently part of the collection; this will support additional research activities, and the further development of the blue bioeconomy. Experience should be gained in growing monoclonoal strains as well as groups of symbionts.

ii. To ensure strain identity over time and reduce maintenance workload, more organismal groups need to be cryopreserved or otherwise maintained under dormancy. Collaboration with the Microbial Resource Research Infrastructure (MIRRI) should be fostered here, and the exchange of good practices between our two institutions promoted.

iii. Experience should be gained in growing in captivity – and even breeding – marine organisms known to produce bioactive substances relevant to the blue-bioeconomy.

iv. Experimental systems and analytical platforms should be tailored towards elucidating life cycles in various lineages of marine model organisms. These systems and platforms should incorporate climate-controlled culture facilities (gradients of temperature, turbulence and light, adjustable spectra, sinusoidal light intensities to simulate natural day-night rhythms).

v. When developing emergent models for research and the blue bioeconomy, research platforms and services for post genomics applications such as quantitative trait locus (QTL) mapping and genome editing technologies should be in place (see chapter on post-genomic tools).

vi. To ensure the ability to scale up production processes, mid-size bioreactors and culture facilities should be made available. Scaling up to industrial levels should only be pursued in a small number of EMBRC sites, particularly where there is a regional interest in industrial-scale cultivation, and funding may be made available for this purpose. EMBRC would be able to seed the reactors from its own collections and operate the facility for the region.

vii. Training should be provided on the maintenance of emergent model organisms and strategies of culturing recalcitrant organismal groups.

Develop post-genomic tools for marine organisms

Strategic drivers

Post-genomic approaches such as phylogenomics, metabolomics, proteomics and system biology are integral parts of many research projects. This is because they allow a wide variety of biological questions to be addressed. Phylogenomics reconstructions are key to fully grasp the molecular basis of the evolution of life (eg speciation, horizontal gene transfer events) and to delineate evolutionary convergences, enabling us to uncover the unique chemical diversity of marine organisms. Proteomics enables the assessment of the biochemical functions of proteins involved in development, metabolism, or gene regulation. Systems biology can allow us to grasp the biochemical and biological functions of structural and regulatory genes and networks, which is key to understanding life histories, physiology, and metabolism of marine organisms.

The acquired knowledge from all these approaches is necessary for the large-scale production of microbial, algal, or animal species of commercial interest. In particular, for algae and bacteria, research in the domain of metabolic engineering can be ultimately applied to the tailoring of cell factories with enhanced performances for bioreactors and land-based raceways. Research in metabolic engineering also provides opportunities for rapid advances in the selection of genotypes with improved performance. This includes the development of strains suitable for intensive and sustainable farming. Such strains should exhibit good growth, disease resistance, and stress tolerance in the context of climate change, as well as feed efficiency and flesh quality for the animal species. Genetic approaches such as genome-wide association studies can also be used to accelerate breeding programmes to develop specific cultivars for the production of marine macro-algae; this can be for human consumption and/or the mining of bioactive molecules.

Strategic recommendation

At many EMBRC Operators, research platforms for Sanger sequencing, quantitative polymerase chain reaction (qPCR), reverse transcription PCR (RT-PCR), and high-throughput sequencing, are operated by dedicated services. This is also the case for bioinformatics. In some cases, these services are even outsourced. On the other hand, various post-genomic approaches are still often in the developmental stage and operated by research teams, essentially for their own use. They can be open to external users, but under a collaboration agreement. Therefore, we recommend that select Operators establish or expand research platforms and associated services for post-genomic approaches, specifically those for:

- Identification of natural products and assessment of their biological activity;
- Functional genomics technologies such as advanced transfection methods, mutagenesis, gene silencing and genome editing;
- High through-put phenotyping techniques at all organisational levels (cells, tissues, whole organisms).

Making non-model organisms amenable to genetic manipulation (see section on Domestication) would create invaluable tools and novel model organisms to develop and advance understanding of the functions of genes and their proteins in all taxa. Gene editing would also be a means of

deciphering key proteins in metabolic or synthetic pathways and would open new possibilities of custom synthesis of interesting candidate molecules. Therefore, we recommend that individual Operators judiciously expand their selection of marine model organisms. This can be achieved by targeting a few species for which there is interest from the research community and/or the blue biotech industry, and which are considered amenable to growth and reproduction in captivity. Research funds should be sought or dedicated to genomic sequencing and assembly, and to adapting post-genomic methodologies to these species.

Experimental systems for studying a changing world

Strategic drivers

The marine environment is evolving rapidly because of global changes, including temperature increases, ocean acidification, and human activities. This rapid transformation affects marine life on top of the pressures it already endures due to over-exploitation and other human activities at sea (ie aquaculture, installation of renewable energy devices). The culmination of these pressures affects the health of the marine ecosystem and threatens our sustainable use of living marine resources. The response of the marine ecosystem to these cumulative pressures is currently unpredictable. What we know is derived mainly from the investigation of single species in heavily-controlled laboratory conditions. Marine ecosystems are more than the sum of their individual species, and therefore, it is risky to draw conclusions on ecosystem functioning based on the results of lab experiments alone. Moving towards a greater understanding of the consequences of all these pressures on ecosystem health requires next-generation experimental systems, which can simulate multiple pressures and assess their effects at ecosystem level.

For EMBRC to support sophisticated ecological research, it needs to offer access to experimental facilities that simulate the marine environment whilst controlling and fine-tuning biotic and abiotic experimental conditions. The portfolio of the currently available experimental facilities in EMBRC is predominantly lab-based. However, several sea-based experimental facilities, such as mesocosms, are also available and allow for *in-situ* experimental approaches. Many of these facilities permit the execution of complex experimental designs in which multiple research questions can be pursued simultaneously. Yet, the planned experiments are usually not advertised widely. Sophisticated instruments to measure and control environmental conditions (eg temperature, pH, light, water currents, and food availability) are available within EMBRC, but are usually deployed in isolation and serve limited goals.

Strategic recommendations

i. Building on this strong basis, EMBRC should invest in the continuous improvement of its experimental facilities. To fully understand the effects of cumulative changes on marine resources and ecosystem health, EMBRC should strive to make modular experimental systems more readily available. In effect, state-of-the art modules could be exchanged between Operators/EMBRC member countries (ie 'nodes'), enabling them to customise experimental facilities to address increasingly complex research questions and meet the associated experimental needs.

ii. Given the availability of various large-scale experimental facilities in EMBRC, a web-based platform is needed where calls can be launched well in advance for external contributions and participation in the experiments.

iii. There is an increasing need to investigate the relationship between biodiversity and ecosystems *in situ*, making it possible to test hypotheses from lab experiments in the real world.

iv. EMBRC should therefore invest in the development and availability of *in-situ* experimental equipment. This can be done for instance in collaboration with other research infrastructures (RIs) (eg AQUACOSM, EMSO). The partnership would enable the deployment of such *in-situ*

experimental facilities in a range of marine habitats, and would also promote the sharing of experiences and good practices.

v. Ongoing developments in experimental faciltiies and their increasing sophistication mean that EMBRC staff need to be (regularly) trained in facility maintenance and operation. In addition, there is a need for standardisation of experimental protocols, reproducibility, and data acquisition. As such, service staff should share best practices and develop a quality label for research services on experimental systems in marine biology, biodiversity, and ecology.

Training and education

Strategic drivers

As a research infrastructure, EMBRC has an important responsibility to train and build capacity within the marine biological research and innovation community. This involves training current and next-generation researchers in new and essential skills through traditionally structured training programmes and lifelong learning. However, it is no longer necessary to develop the next training course for academia and industry. The training sector is changing and learning habits are evolving, meaning that EMBRC must plan to stay relevant in the training space. We must work to ensure the training platform MarineTraining.eu is well-placed to facilitate different types of training and education opportunities.

EMBRC offers a wide variety of facilities, know-how and expertise. To ensure the best use of these, EMBRC must benchmark itself as an ideal ecosystem for training potential users. Training needs to take place in a variety of forms for both internal and external stakeholders.

Strategic recommendations

The following three key activities should provide opportunity to grow and evolve, ensuring the continued relevance and central position of the MarineTraining portal:

i. Act as a 'facilitator' in the marine training landscape at both EU and global level. Maintain the MarineTraining portal so that training seekers will be able to find trainings and training resources. This facilitating role has several advantages: (1) EMBRC will be able to link easily to other relevant networks working in the context of ocean capacity development, (2) training is an excellent promotional tool and users of the portal will learn about EMBRC and may become users of the infrastructure, (3) the data collected via the portal can be used to provide advice to policymakers on reshaping the future of the marine education landscape.

ii. Link international graduate programmes that use EMBRC in the best possible way. The IMBRSea master's programme, for example, is organised by a network of several EMBRC Operators where courses, internships, and thesis work takes place. Moreover, this kind of programme offers an ideal opportunity to train young marine scientists on how to use available resources. Through these programmes, they may acquire skills and know-how which will serve them as future potential EMBRC users.

iii. Continuously invest in professional development. Ensure that EMBRC can continue to train both internal and external users via short, face-to-face courses and training modules, while making training materials available to them.

Access & Benefit Sharing (ABS) compliance of EMBRC sites and bioresources

Strategic drivers

As a provider of biological resources for research and innovation purposes, EMBRC must uphold the highest standards in terms of ethics and compliance with animal, research, and exploitation legislation. The Nagoya Protocol and the subsequent Access and Benefit Sharing (ABS) regulation came into force in 2014. They introduce requirements for users of genetic resources to have proper documentation proving legal acquisition of the resources from the country of origin, the terms under which these resources may be used, and how any benefits arising from this utilisation will be shared with the country of origin. This imposes additional, limiting requirements on researchers. EMBRC can help its users by facilitating access to marine genetic resources and supporting individuals to exercise their due diligence. EMBRC has carried out multiple activities regarding compliance with ABS regulations, including the development of best practices and audits of all collections in the pp2EMBC, EMBRIC, and EBB projects. However, EMBRC has been slow in adopting its own tools and recommendations and is consequently starting to lag behind other research organisations.

Strategic recommendations

i. EMBRC must ensure full compliance with the ABS framework and implementation of best practices for its biological resource centres (BRCs) and culture collections (CCs), bringing them to the same high standards. EMBRC BRCs and CCs must carry out the following activities to become compliant with ABS legislation:

   - *Validation and adoption of ABS best practices:* EMBRC must review all existing efforts from previous projects and implement them across the organisation. Multiple recommendations and tools have been proposed and they should be implemented. Ultimately, EMBRC should be in a position to facilitate, as much as possible, access to marine genetic resources for its user communities, and improve awareness and comprehension of the ABS framework.

ii. *Inventory of compliance of organisms:* In order for EMBRC to supply organisms in full compliance with ABS legislation, BRCs and CCs must first understand where their samples come from, the ABS legislation for a given country, and whether or not additional authorisation is needed to continue to supply the organisms for research purposes. Where appropriate, retroactive permission (Mutually Agreed Terms, MAT) for distribution to third parties for research purposes must be requested.

iii. *Facilitate access to local marine genetic resources (MGR):* Each EMBRC node (ie country member) must ensure that they can readily supply their local biodiversity according to national laws. In addition, where necessary, they must be able to obtain authorisation from the relevant national authorities to continue to distribute national biodiversity freely to users for fundamental research purposes. It will be up to all users to renegotiate the relevant MAT with the country of origin in case of commercial exploitation of MGR.

Data ‘FAIR-ification’ and support

Strategic drivers

Scientific research is increasingly driven by large, complex datasets, and marine biological sciences are no exception to this trend. Data generation is often costly and limited to small numbers of sites or organisms. It is therefore essential to ensure that data are Findable, Accessible, Interoperable, and Reusable (FAIR). FAIR data allows for aggregation into high-value datasets with broader scope to ensure long-term preservation without loss of informational contents. In addition, FAIR data means avoiding third-party data curation/annotation efforts or duplication after dataset publication.

Data are an important resource and product outcome of EMBRC activities. As such, they must be managed and curated, and treated to the highest to standards of scientific excellence. EMBRC data is categorised as one of 3 types:

- **Type 1** data are generated through EMBRC services by its users. EMBRC has no claim to these data and they belong exclusively to the user.
- **Type 2** data are generated through EMBRC-led activities (eg Ocean Sampling Day) carried out as part of European-funded projects. EMBRC is responsible for their storage and owns all rights to their use.
- **Type 3** data are generated by EMBRC institutions but belong to the respective institutions and researchers (eg LTEDS).

The metadata annotation standards landscape can be challenging for scientists who are not primarily concerned with annotation of data. This challenge is often exacerbated when, at the time of data collection, there is insufficient comprehension of the data. Training initiatives are already provided by the main actors in the field, RIs or projects (ELIXIR, ASSEMBLE Plus, SeaDataCloud, EmodNet) to raise awareness about data management best practices and to help scientists add metadata to their datasets.

Strategic recommendations

At the EMBRC level, projects susceptible of generating data will need to formalise data management in a specific Data Management Plan, required for project evaluation.

To ensure consistency of data management (DM) best practices across EMBRC projects and to raise overall data quality for EMBRC datasets, scientists using EMBRC services should have access, at all stages of a project’s lifecycle (from application to result dissemination), to a common set of DM resources.

i. *Data guidelines:* EMBRC must work to produce short, concise guidelines for marine data generators, outlining the major data standards (including for metadata) and for what data types they are used. This document will be available through the EMBRC website and be provided to all EMBRC users at the point of project acceptance.

ii. *Training Initiatives:* Existing training opportunities from ELIXIR, EmodNet, and other similar organisations will be heavily promoted throughout the community. In addition, a gap analysis will be carried out to identify marine-specific needs that may not be covered by others. Where necessary, new courses will be developed in conjunction with the major data repositories.

iii. *Data help-desks:* Finally, due to the complexity of data and the complicated landscape around e-infrastructure, EMBRC must implement a network of data experts providing a help-desk service. Through this service, researchers will be able to receive guidance and advice on their data-related issues. Such a service should be accessible for users when on-site and in the three months following an on-site visit, as well as for remote/virtual access. The help-desk will provide one-on-one advice on specific projects.

iv. *Data quality control:* The need for quality-assured marine biological data has never been greater. In order to increase trust and transparency in data and data products resulting from EMBRC activities (Type 2 data), clear and robust quality assurance and quality control procedures must be identified and applied wherever applicable. The steps that each dataset have undergone through the data lifecycle must be recorded, with direct URLs to QC protocols where available, in the dataset metadata. Data 'provenance' should be adequately detailed to provide the end-user with sufficient information to inform their subsequent use. These steps of quality control are also relevant for the European Open Science Cloud (EOSC), to avoid the EOSC consisting of raw data.

v. *Data FAIR-ification and Open Science:* EMBRC data are categorised into 3 types, and the actions needed to improve the FAIR-ness of each type will differ. For Types 2 and 3, EMBRC will increase data 'Findability' by including metadata descriptions of the datasets and linking them to their respective repositories, where they can either be 'Accessed' by download or upon request. Type 2 data will always be made 'Accessible' as this type of data is collected by EMBRC and its sites. With respect to Type 3 data that is collected but not made accessible by the EMBRC site, EMBRC will encourage and educate researchers on the benefits of Open Science and the application of FAIR principles. Type 1 data is collected by EMBRC users and, as such, they own the rights to the data and will be responsible for data management. In order to encourage the implementation of FAIR data practices for this data type, EMBRC will initiate training and workshop opportunities for its users. Furthermore, EMBRC will organise training within the EMBRC sites to create a common understanding of FAIR principles and Open Science. By building expertise in Open Science and FAIR practices at the EMBRC sites, these principles will become more widely acknowledged and practiced, thereby increasing the number and quality of datasets produced by EMBRC.

Promoting long-term data series through EMBRC

Long-Term Ecological Data Sets (LTEDS) are one of the most important data sets for marine ecology, climate change, and environmental research. However, providing easy access to them remains a challenge. As a Type 3 data resource, EMBRC has no control over them. Nonetheless, they remain an important component in enabling a vast amount of marine biological research, and could be considered the particle accelerator equivalent of the field. EMBRC has an opportunity in improving the use and impact of these datasets and will:

i. *Improve visibility and facilitate accessibility:* In a first instance, EMBRC can improve the visibility of LTEDS by promoting their use and providing links to their location. In addition, EMBRC will make its data guidelines, produced through ASSEMBLE Plus, available to any LTED provider wishing to collaborate with EMBRC.

ii. *Integrating GOs with LTEDS:* The deployment of genomics observatories (GOs) in EMBRC provides an exciting opportunity to add a genomic dimension to LTEDS. EMBRC will seek to incorporate the GO protocols to LTED sampling sites, ensuring the seamless integration of GO data with that from traditional sampling. As such, LTED data will be supplemented, and this will provide additional justification for ensuring the maintenance of LTED sites.

iii. *Align marine and terrestrial LTED efforts:* EMBRC should engage with eLTER to work on shared standards to achieve interoperability in data collection and ensure comparability of marine, aquatic, and terrestrial LTEDS.

Prioritisation and distributions of efforts

Achieving the ambitious developments and goals of this strategy will require broad deployment of resources and efforts. It is not possible to accomplish this with EMBC membership funding alone. The strategic recommendations in this document reflect the needs of the various communities supported by EMBRC across Europe. The goal is to enable them to remain competitive on the global level and push the frontiers of science. This document thus provides a roadmap for EMBRC to enhance its capabilities and provides a basis for its country members (ie the nodes) to request and justify financing of specific activities for the benefit of the entire community.

EMBRC will pursue and seek to develop the activities that require central organisation, coordination, leadership, and/or deployment. These include the GO network, ABS objectives, data requirements, the set-up of a coordinated bioprospecting service, and the management and development of the EMBRC website. Regarding the GOs, we must ensure the use of common standards, and most importantly, the openness of and free access to data. In terms of the successful deployment of the GOs, a phased approach is recommended. This should start with in-shore sampling, the testing of the concept and EMBRC's ability to coordinate multiple sampling sites, followed by the rollout of ARMS devices, and finally, the soft sediment protocols.

For activities related to node expertise and needs (such as 'omics' tools, new experimental platforms, and domestication of further lineages of marine organisms), the nodes will pursue these activities. This will be done on an individual basis, or in collaboration with other (like-minded) nodes, according to national priorities and capabilities, and with the support of national and European research projects and instruments.

Conclusion

EMBRC is the only marine research infrastructure (RI) in the field of biological and medical sciences, as well as the only RI in biology and ecology for marine sciences. As such, it must closely monitor its user communities, their needs and trends, in order to stay relevant and provide leadership in its domain. Thus, EMBRC is proposing to expand its capability and influence in the following ways:

- Provide the first RI service on marine biodiversity observation, an ambitious move, that will provide the baseline data currently missing for exploring and understanding marine biological diversity;
- Strengthen and develop pipelines and capabilities for marine biodiscovery and spearhead interdisciplinarity to harness and apply technologies from other scientific domains and develop models towards market exploitation;
- Increase our ability to master and provide access to as many representatives as possible from the tree of life, improve our ability to manipulate them, and adapt new approaches and techniques to ensure the relevance of marine models;
- Provide new experimental platforms and offer access to large-scale marine facilities and experiments to support current research trends;
- Champion data standards, FAIRification, and implementation of ABS standards in marine biological sciences;
- Provide leadership and state-of-the-art training to the marine research community and the next generation of marine scientists; and
- Promote the sustainable exploration and exploitation of marine resources and growth of the blue bioeconomy in partnership with companies and governmental and non-governmental organisations.

These are ambitious goals and will require the full support of EMBRC Operators, the EMBRC General Assembly, and the EMBRC user community. These developments will ensure the ability of researchers to push the frontiers of science; the RIs' capacity to support companies in their innovation goals; and Europe's aptitude as a leader in marine biological research.