



**EMBRC**  
EUROPEAN  
MARINE  
BIOLOGICAL  
RESOURCE  
CENTRE

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**EMBRC scientific strategy**  
**Report**  
***Deliverable D2.5***

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**2013**

**The EMBRC preparatory-phase**



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## 1. Executive Summary

The EMBRC Scientific Strategy Report informs and advises the General Assembly (GA), Steering Committee (SC), Work Package (WP) coordinators and officers as well as the wider community on how EMBRC will be established and will operate as a European marine research infrastructure. The Report describes the strategic service areas and standards of EMBRC and proposes mechanisms needed to maintain the research infrastructure (RI) at the forefront of future scientific developments. The Report also provides recommendations and guidelines for services and collaborations to ensure close interaction with other ongoing and forthcoming European programmes and ESFRI projects.

The report specifically provides recommendations and guidelines regarding:

- Infrastructure requirement to meet user demands, including e-infrastructure requirement for present and future services,
- Interoperation with European programmes and ESFRI RIs,
- Joint Development Activities
- Knowledge and Technology Transfer

The implementation phase of EMBRC, starting in 2014, will see the initiation of EMBRC in a limited capacity. Activities will focus on the organisation of infrastructure, interactions with other ESFRI and EU initiatives and the co-ordination of ppEMBRC partners in preparation for the Operational Phase and delivery of the scientific strategy.

Infrastructure priorities include:

- Creation of a web-based searchable EMBRC services, facilities and organism database.
- Creation of a best practice database to achieve high and compatible standards in experimental methods, culture and husbandry, data collection and analysis.
- Establishing bioinformatics platforms to meet the demand for 'omics-based research in accordance with WP3 e-infrastructure strategy (D3.3) and improved communication with RIs currently developing such facilities (e.g. ELIXIR).
- Implementation of a mechanism to coordinate the access programme for mobility of researchers.

Service priorities include:

- Cementing EMBRC in the strategic research landscape in Europe, through close collaboration and dialogue with other RIs, EU funded projects and national and international research projects.
- Creating a knowledge and technology transfer (KTT) platform to provide industry and SMEs with a go-to service for accessing scientific data and research relevant to their R&D.
- Joint Development Activities (JDA)
- Training

## 2. The purpose of the document

This is **primarily an internal working document** that sets out the strategic priorities, the requirements to address them and mechanisms for implementation.

## 3. Introduction

The oceans represent the largest set of ecosystems on Earth from polar seas to extreme deep-sea and hydrothermal vent environments. They harbour exceptionally high biological diversity. Consequently, marine organisms exhibit an extraordinary variety of often unique structures, metabolic pathways, reproductive systems, and sensory and defence mechanisms. Accessing and understanding this biodiversity is highly relevant for the sustainable development of human society, underpinning advances in biomedicine, biotechnology and food security, as well as providing increased awareness of environmental issues and the value of ecosystem services. European and national policies emphasise the need for state-of-the-art research, education, training and innovation in order to meet the Grand Challenges that currently confront European development and wellbeing.

Marine sciences are undergoing a major revolution with the consolidation of experimental, monitoring, 'omics and analytical approaches driven by advances in technologies, making marine models and ecosystems more accessible to the wider scientific and industrial communities. Along with their value as experimental models marine organisms provide novel genes, pathways and compounds of importance for a range of biological applications. Examples include fluorescent protein reporter molecules in cell biology, novel substrates and technologies for bioscaffolding and micro and nano models for structural engineering and nanotechnology. Marine biological research is rapidly developing new foci on complex interactions at sub-cellular to ecosystem levels and the sustainable utilisation of marine resources. EMBRC will be central in the development of "blue biotechnologies" providing new opportunities for bioprospecting and bioharvesting (bio-discovery techniques); bioprocessing, bioremediation (process biotechnology techniques), aquaculture and fisheries.

Europe has a very long and distinguished history in marine biological research and its coastal marine biological centres are amongst the oldest in the world, with many having been established in the 19<sup>th</sup> century. They provide transnational infrastructure sites to serve, enhance and develop marine research worldwide. Marine research laboratories play a unique role in providing platforms, equipment, expertise, resources and information to enable the study of marine biodiversity and ecosystems. However, these marine laboratories have traditionally tended to operate as independent research infrastructures, providing stand-alone access to marine organisms, ecosystems and facilities for visiting and resident researchers.

To foster better integration of European marine research resources the FP6 Integrated Infrastructure Initiative (I3) project ASSEMBLE (2009-2013) created a network of leading European coastal marine biological research centres. ASSEMBLE has brought together

improved transnational access to a range of marine ecosystems, model organisms and experimental systems along with state of the art approaches to their study.

However, it is widely agreed that simply increasing access to marine centres is not in itself sufficient to meet current and future needs. Marine RIs need to be supported and co-ordinated at the European level in order to address future demands for marine resources, to seize the opportunities presented by better understanding of marine systems and to meet the challenges of increasing uncertainties about the changing marine environment. A co-ordinated infrastructure that fosters sharing of knowledge, expertise and facilities is required to meet current and future demands arising from rapid and substantial advances in technology. Increasingly, no single marine centre can provide all of the requirements of modern interdisciplinary science. These include large and expensive technology platforms, co-ordinated data acquisition, transfer, analysis and storage, development of unified standards and best practices, along with increased cost-effectiveness associated with facility sharing and avoidance of unnecessary duplication. The marine centres themselves need to be better organized on a European scale to respond more effectively to infrastructural demands in an economic reality and limited financial resources.

## 4. EMBRC Aims and Goals

EMBRC will:

- 1) Become the major European provider of marine biological research infrastructure and related services, providing a single access point to world-leading facilities, marine ecosystems, data and time series. This will benefit the whole of the research community, from academic to commercial users, by providing access to platforms and resources otherwise beyond physical and financial reach. Access to the RI will be provided at full economic cost, based on scientific merit for academic users and feasibility for industrial users.
- 2) Provide co-ordination and leadership through a strong management structure, joint development activities, scientific and strategic meetings and workshops that will catalyse research partnerships, inform the planning of future funding initiatives and provide an important input for planning of future infrastructure requirements.
- 3) Foster mobility of European researchers between member states and between industry and academia.
- 4) Ensure standardisation of data collection, storage and transmission, workflows and skills training along with implementation of best practise in research methodologies and technologies.
- 5) Develop a knowledge and technology transfer platform that will facilitate innovation. EMBRC will increase economic well-being and enhance quality of life through job creation and by bringing research discoveries to applied services and products.

- 6) Provide high quality infrastructure for training and education.

## 5. EMBRC Service Priorities: Outline Strategy Papers

The following groups represent the **core areas of service provision**. This section outlines the rationale for their inclusion, an outline of the expected users and the strategic requirements of EMBRC to develop these services.

### 5.1. Access to Ecosystems

#### 5.1.1. Strategic Drivers

Marine biological resources present many under-utilised opportunities for the European RTD community for fundamental and strategic research (including biomedicine and biotechnology) and for understanding sustainable resource management and the impacts of environmental change. As the use of model organisms is rapidly gaining in importance for research there is a growing need for *in situ* studies on these organisms in their natural environment to understand their biological responses and potentials. Ecosystem access services will be critical for governmental and industrial users, as well as the wider research community. EMBRC will provide, as a core service, ecosystem access to a large number of shore and near-shore habitats, from sub-tropical to polar seas, as well as extreme habitats such as oxygen-poor and deep-sea realms, as well as access to artificial habitats for biofouling research and renewable energy test sites.

Ecosystem Access covers:

- i. *Physical access*: The marine centres operate a number of research vessels ranging from large, modern, open ocean state-of-the-art research vessels to coastal tenders that service buoys and collect local samples. There are also a number of Remotely Operated Vehicles (ROV) available as well as scientific diving centres.
- ii. *Access to data*: EMBRC will become a gateway to the data that are regularly gathered into time series of marine species and habitats, many of which have been regularly sampled for decades and thus comprise unique long-term databases of environmental change.
- iii. *Access to local expertise*: Visiting users will benefit from local knowledge for specimen identification, collection and biological information, along with habitat or ecosystems characterisation and they will benefit from the extensive general background knowledge of the staff throughout the EMBRC RI.

### 5.1.2. Strategy recommendations

- **Establish an EMBRC Services Database of habitats, organisms and cultures, platforms/equipment, databases and local expertise (link with WG-2: Aquaria & Culture & WP-3 E-Infrastructure).** In order to provide a fast and effective over-view of available services for users it is important that EMBRC advertise and list the services provided. The database will be searchable online through the EMBRC website. The list will cover the following aspects:
  - i. *Habitats:* All habitats available through EMBRC partners, or schemes accessible through an EMBRC partner, should be identified according to EUNIS (*European Nature Information System*) habitat classification system for species, habitat types and sites). This will also ensure that a search carried out on the EUNIS website for particular types of habitat will list the habitats available through EMBRC, increasing the network's exposure.
  - ii. *Species:* EMBRC will supply either cultured (including mutant strains) or collected organisms for dispatch or for use in the hosting centres. Species names will be formatted according to WoRMS (World Register of Marine Species) names database. Distinction, along with information on availability (e.g. seasonally). Links to other large existing culture collections within EMBRC (e.g. The Roscoff and SAMS culture collections) will be established.
  - iii. *Time series Datasets:* EMBRC will provide access to a unique and extensive array of marine time-series datasets from the various centres. A catalogue of these will provide direct links to centre website access portals (and user agreements conforming to terms and conditions).
  - iv. *Platforms and equipment.* Physical infrastructure available through EMBRC (research vessels and seagoing equipment, scientific diving platforms, aquaria and culture facilities, imaging and microscopy platforms, omics platforms, other facilities, e-infrastructure, supportive facilities, teaching and seminar facilities and housing) will be listed in the services database,
  - v. *Expertise:* Collectively the EMBRC centres host an exceptional range of expertise of great value to visiting researchers, (examples include taxonomic expertise, laboratory skills for molecular applications, sophisticated imaging techniques and local habitat knowledge). An added value of EMBRC is that the local background knowledge of all centres will be integrated into a single access point.
  - vi. *Libraries and information services:* Much information about local habitats and ecosystems is held in library collections. EMBRC will provide information about library resources of its nodes. Priorities will include digitisation of archive materials to be made available in the EMBRC website.

The EMBRC database will be of great importance to EMBRC users and the research community as a whole. It will serve as the first point of call for interested users to explore the facilities and services available in the EMBRC access programme. The EMBRC database

can in the future be used to inform other directories and existing databases, such as EUNIS or EUROCEANS and thereby provide a comprehensive service for a large user community.

The database should be constructed and managed by suitably qualified IT expertise in connection with website development. An accurate, first version of the database linked with the EMBRC website must be a high priority of ipEMBRC. Throughout operation the database must be regularly reviewed and updated to ensure accurate display of EMBRC services.

- **Expand Ecosystems/habitats available for access.** Currently EMBRC partners have access to a wide range of warm-temperate to polar ecosystems. It will be essential that access is adaptable to meet the future needs of the independent research community and industrial R&D. Access to sites with high anthropogenic impact (i.e. marine environments created, or significantly altered, by man such as marinas and artificial reefs) should also be secured. Access to off-shore technology, renewable energy platforms and monitoring where their *in situ* impacts can be assessed should be investigated through links with MARINET.
- **Expansion and Improvement of Scientific Diving Infrastructure.** Scientific diving accessible to visitors is available within EMBRC, but is not a service that is utilised to its full potential. Efforts need to be focused on consolidating the diving centres and on providing adequate facilities. This was identified as an infrastructure gap in D2.3 Strategy Report on New Infrastructure Requirements (see D2.3. Section 2.1.2 Scientific Diving Infrastructure).
- **Improve local taxonomic services.** Taxonomic services are available in many stations. However, taxonomic expertise has become rare and no single centre can provide the breadth of knowledge required of the research community. Providing classical and modern taxonomic support across the infrastructure will be of enormous value to specialist researchers in other disciplines (e.g. biomedical and biotechnology researchers) requiring in depth taxonomic information to those users visiting an area for the first time and users new to the marine field
- **Harmonise long-term datasets and data collection.** Currently the provision of information and data lack an integrated European approach and large scale visibility. Ecological databases range in space and time scales from those developed in the frame of specific research programmes to large scale European databases (e.g. MarBEF). A number of initiatives are required so that standards and quality control can be readily assessed for implementation across EMBRC, for (1) metadata collection and standardisation (e.g. INSPIRE directive, MEDIN), (2) taxa names (e.g. WoRMS), (3) habitats classification (e.g. EUNIS) (4) data acquisition (e.g. ICES, QUASIMEME, Genomics Standards Consortium (GSC), TARA OCEANS recommendations and protocols, or more locally Interreg Programmes). Existing large scale databases such as the international databases PANGEA or MarBEF and more local initiatives (e.g. VLIZ, Flanders Marine Institute), should also be considered. Close collaboration with ESFRI initiatives, such as ELIXIR and LIFEWATCH, will play a crucial role in determining how data is managed, shared and processed within EMBRC.

It is essential that the drive to participate in and utilise European-wide database initiatives is maintained within EMBRC. This will facilitate the integration of ecological data acquired by European marine centres and improve access to the user community. Standardising data

and collection methodology is an important step towards ensuring that Europe remains a leading force in marine ecological research. However, the adoption of standards and their implementation that may involve large-scale changes to procedures, data collection and the formulation of new guidelines, require coordination across centres and time. It is recommended that a workshop is organised at the onset of the implementation phase to discuss database and standardisation options with the aim of implementing the agreed improvements during the implementation phase in the medium term by 2017.

## **5.2. Aquaria and Culture**

### **5.2.1. Strategic drivers**

Aquaria and culture facilities for both macro- and microorganisms are at the heart of any marine research centre. ASSEMBLE has demonstrated the demand for on-site and remote access to marine biological resources within Europe for ecological, ecotoxicological, physiological, evolutionary and biomedical research projects. A majority of applications have required access to aquarium facilities for maintenance or experimental work.

Biology is in the midst of a revolution driven by the development of “model” organisms along with high throughput ‘omics technologies and increased computing power, which are bringing fundamental advances in understanding. Model organisms are characterised by particular biological features, which make them tractable for studying a particular set of processes. Whole research communities build up progressively around each model species facilitating the development of biological (e.g. mutant strains) and molecular (genome sequences, transcriptomes, proteomes, antibodies, tools for functional analysis) resources. An analysis of the ASSEMBLE applications indicates there is demand for a broad range of species at present. Moreover, an ever increasing number of important model animal species with annotated genomes is becoming available. In parallel, continuing advances in high throughput sequencing technologies are allowing genome scale studies on non-model species which are likely to increasingly impact on population genetics and ecology, fields which underpin stock assessment in fisheries and climate change research.

These advances will have important consequences for the development of the EMBRC aquaria and culture facilities. Firstly, there will be a need for improved technology for the sustainable culture of high demand species. Secondly, EMBRC partners will have to anticipate changes in demand for a range of biological resources and services in response to increasing and changing priorities and societal challenges.

Consequently, there is a requirement to maintain aquaria and culture facilities adjacent to a wide range of cold, cool temperate and warm temperate ecosystems throughout Europe. There is a particular demand for developing aquaria capable of better simulating natural environments which will require further development work. EMBRC should identify such facilities and promote their development with a view to addressing basic and applied research questions (impacts of marine renewables, climate change etc.).

### 5.2.2. Strategy recommendations

- ***Incorporate the aquarium facilities*** of the EMBRC partners into the EMBRC access programme. Access will be provided to a broad range of facilities for culturing and maintaining aquarium-reared or collected marine organisms from sub-polar to sub-tropical environments. Facilities will also be available for manipulation of environmental parameters (e.g. temperature, pH, light) for experimental purposes.
  
- ***Identify and disseminate best practice*** for aquarium and allied facilities throughout EMBRC. To achieve this goal EMBRC will adopt the best practice guidelines for Biological Resource Centres developed by the Organisation for Economic Co-operation and Development (OECD) in 2007. The following areas should have priority:
  - i. Water quality standards including biological and non-biological filtration systems, pumping technologies and sanitation.
  - ii. Environmental control technology and automation systems, particularly the provision of electronic metadata to users.
  - iii. Biological security, including disease control, quarantine and containment of biohazards e.g. genetically modified organisms. The danger of inadvertent introduction of non-native species in new areas due to dissemination of marine organisms through research activities needs to be specifically addressed through strict control of discharged aquarium water.
  - iv. Joint Development Activities to close the life cycle of high-demand organisms to facilitate their sustainable culture, the development of optimal culture conditions and nutrition, enacting methodologies to ensure the phenotypic and genotypic stability of cultured strains, and the duplication of key genetic resources in multiple sites in accordance with international guidelines.
  - v. Environmental standards particularly in relation to energy usage and waste water treatment.
  - vi. Staff-training and education in culture and husbandry techniques through EMBRC organised workshops, in particular techniques and services related to on-site access, remote access, animal transportation and handling of organisms and samples. The outcomes of such workshops should be included in EMBRC technical reports to be shared widely amongst nodes and visitors.

The Aquaria and Culture Systems Working Group will be tasked with the organisation of periodic workshops on the above topics for professionals in the academic, governmental and commercial aquarium sectors under the auspices of the anticipated EU-funded access program. The reports arising from these workshops will provide guidelines for harmonisation of procedures and standards and for optimisation of technical solutions for aquaria, culture and related issues between the partners. Joint Development Activities will be carried out to provide technical solutions to problems identified by the WG. For staff training funding will need to be identified to facilitate mobility of staff for short visits in partner facilities to disseminate best practice and for knowledge transfer.

- **Co-ordinate and exchange information with related EU-funded programmes for marine biological resource provision**, particularly MIRRI (microbial culture collections), AquaExcel (aquaculture resources), Mesocosm Access and LIFEWATCH to avoid duplication of effort and provide a seamless access to services. This will involve the sharing of best practice for technical solutions workshops with allied RIs. An access process will be required to allow applications to be diverted to the most appropriate RI. Such co-ordination is particularly important with respect to culture collections where EMBRC partners (SBR, SAMS and MBA, AWI) have important national collections of algae and protozoa. EMBRC should work with culture RIs (e.g. MIRRI) to ensure the security of collections through the transfer of organismal cultures to additional sites.
- **Preserve biodiversity.** EMBRC should formally analyse the conservation requirements associated with on-site and off-line access to marine species as part of the application process to the infrastructure. Limitations should be put in place to ensure that removal of organisms from habitats is sustainable and conducted in the least invasive manner possible. This should also involve providing facilities and expertise to maximise local knowledge of the biology of available species through generating written documents and training a new generation of experts locally.
- **Promote best practice in animal welfare and ethics.** Experimentation and welfare guidelines for cephalopods, chordates and vertebrates are already covered by extensive National and European legislation and are highly regulated. EMBRC needs to work with partner Institutes and national authorities to facilitate trans-border use of regulated facilities. This could involve help with meeting National license requirements through training and/or the identification of collaborators with license authority at the site of access. An EMBRC Animal Ethics Committee should be established that will engage with the Animal Welfare and Ethics Committees in the partner Institutes or other bodies to identify minimum standards which would allow a common system of approval for non-regulated animal use throughout EMBRC.

## 5.3. 'Omics Technologies

### 5.3.1. Strategic drivers

Core 'omics technologies, represented by genomics (DNA), transcriptomics (RNA), proteomics (proteins) and metabolomics (metabolites), are typified by high throughput analysis of molecular or biochemical classes. They represent some of the most powerful and widely used technologies in modern biology. This strategy report also considers 'omics-associated technologies, including functional approaches (cell biology, electrophysiology, microscopy, NMR imaging and spectroscopy).

'Omics approaches increasingly underpin advances in basic biology, biomedicine and biotechnology. Specific examples include exceptional advances in understanding of phylogenetic and evolutionary processes, developmental biology and signalling; Nobel Prize winning work with fluorescent proteins and their derivatives; antibiotics discovery and pharmaceutical development. 'Omics approaches also have the potential to unlock a deeper

understanding of ecological and biogeochemical processes and to provide better resolution of information at all levels from the molecular scale to the population level. In the environmental sciences, metagenomics is bringing new understanding to microbial-dominated pelagic ecosystems and biogeochemical drivers. Coupling with the increasing availability of extensive physical, chemical and biological metadata offers the potential for extensive systems biology analyses of communities, ecosystems, and processes.

Many advances in biotechnology are underpinned by 'omics technologies. The *ESF Marine Board Marine Biotechnology Strategy*<sup>1</sup> underlines the central role of 'omics approaches as a basic toolkit for research. The potential of deep sea and polar biodiversity has yet to be exploited for 'omics models and biotechnological potential. Within Europe, there are well-established capabilities comprising research vessels, husbandry, organisms, access to ecosystems, mesocosms and long-term time series datasets that will underpin the potential of 'omics. This is backed by considerable expertise in biochemistry, metabolism, physiology and ecology of marine organisms that is essential for understanding, interpretation, and annotation of genomes and other types of high volume data. 'Omics technologies are allowing scientists to diversify away from some of the well-established models to study organisms and systems that were not previously tractable but which now provide new models for ecology, genomics, biotechnology or the study of specific processes (see D3.2 *Detailed evaluation of potential e-workflow scenarios* for more details). At the same time 'omics approaches are reinforcing the value of well-established model systems

A further significant driver for 'omics technologies is the unparalleled growth in capacity for data gathering and analysis and the decreasing costs of data acquisition and storage. A range of platforms for sequencing and analysis are accessible at national and international levels. There are a number of national 'omics facilities that serve partner organisations but these are not currently available to the EMBRC community as a whole. The majority of high-end sequencing platforms are not specifically marine-oriented<sup>2</sup>. 'Omics-related facilities that provide functional analyses (e.g. microscopy, NMR imaging and spectroscopy, cell biology, culture collections, cryopreservation facilities) are often by necessity centre-specific and widely dispersed. There is a clear need for better provision of advice on where to go for the best or most appropriate service. EMBRC will need to develop an understanding of the provision for sequencing and other 'omics data in Europe in order to provide advice to its users.

There is a well-recognised and increasing dearth of expertise relating to bioinformatics analysis and biological interpretation of 'omics data among European institutions. In particular there are increasing training needs in the areas of annotation, curation, assembly (including use of software tools<sup>3</sup>), genome structure and organisation and experimental design and statistics. Raising awareness of the problems of data analysis is a major challenge. There is also a perceived lack of integration of dispersed resources and an increasing need for standardization of collection and analysis. There is a lack of international data sharing agreements and a potential longer term problem relating to data transfer and

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<sup>1</sup> ESF Position Paper 15: Marine Biotechnology: A new vision and strategy for Europe. . . . .  
[www.esf.org/marineboard](http://www.esf.org/marineboard)

<sup>2</sup> SB Roscoff has a dedicated marine proteomics/protein structure platform.

<sup>3</sup> e.g. Web-based tools such as Ensemble genomes at EMBL-EBI ([ensemblgenomes.org](http://ensemblgenomes.org)).

storage which underlines the need for input into the development of the EMBRC e-infrastructure network.

In relation to environmental genomics, the substandard status of molecular taxonomy of marine organisms (especially microorganisms) is a brake to large scale metagenomics and environmental studies. Better integration between long term and historical datasets, biological resource centres and 'omics repositories is needed. The potential of systems biology approaches in linking biological and biogeochemical processes at hugely different scales is under-developed. There is a pressing need for clarification of what support and infrastructure is required to realise the full potential of 'omics technologies.

Threats to the realisation of 'omics potential are both 'omics-specific and generic. Specific threats include the potential diminishing of available human resources in this area and the danger that technology becomes obsolete faster than the training that is possible for the resource available. The most significant generic threats relate to current economic factors. National priorities for funding of research may shift at relatively short notice. There is a danger that national funding bodies may become less willing to support "overseas" 'omics research and infrastructure developments.

### 5.3.2. Strategy recommendations

- **Development of tools and technologies.** The co-ordination of 'omics tools and capability throughout Europe and establishment of marine-oriented 'omics standards for design and analysis needs to be facilitated to provide a framework upon which 'omics approaches will be developed throughout the infrastructure. These include:
  - i. The development of standardized 'omics related technologies, specific for marine organisms, such as sample preparation, storage, quality control and validation,
  - ii. The development of coordinated 'omics data handling tools and expertise
- **Establishment and co-ordination of training programmes**
  - i. Dissemination of training tools is an urgent short- and long-term priority for 'omics development throughout the EMBRC. This should be achieved by increased resources for training at all levels, including greater investment in training infrastructure within EMBRC.
  - ii. Training in data handling and analysis (curation, assembly (including use of software tools), genome structure and organisation and experimental design (including arrays, RNA sequencing) and statistics) should be prioritised over data generation in the immediate and medium terms. This should be done in conjunction with ELIXIR.
  - iii. The convergence of requirements between EMBRC and EuroMarine for immediate emphasis on training needs to be acknowledged through close

integration and alignment of training programmes, particularly during the development of the EuroMarine strategy.

- iv. Training should be linked with continuous Professional Development (CPD) to maximise retention of trained personnel and career development.
- v. A wide range of training schemes and programmes should be implemented to address the different requirements of functional, environmental<sup>4</sup> and “meta” Omics approaches.<sup>5</sup>

- **Platform access and co-ordination:**

- i. The availability of centralised ‘omics platforms that provide outsourced services for large scale sequencing needs to be considered in the development of ‘omics facilities for the EMBRC community. The cost-effectiveness of maintaining marine-specific or centre-specific facilities of this nature should be assessed in the face of rapidly changing technology and the increasing numbers of commercial and centrally-funded facilities elsewhere at an international level. While the benefits of “complete” marine ‘omics facilities should not be discounted, lower priority should be given to the construction of large scale ‘omics facilities, such as new whole genome sequencing centres specifically for marine research.
- ii. In the meantime, priority should be given to the development of small scale ‘omics central facilities at each of the partner centres to serve as pilot labs for small scale focused experiments, for sample validation and for preparatory screenings for large scale experiments. These facilities will be key to the development of approaches tailored to specific organisms.
- iii. Priority should be given to specific centres for infrastructure and expertise where appropriate for specialist ‘omics-related capability. Examples include analytical facilities<sup>6</sup>, electron microscopy, micro-CT tomography, protein biochemistry and construct preparation<sup>7</sup>. It is acknowledged that facilities for live cell imaging generally need to be centre-specific. However, high-end live cell imaging is costly in terms of capital investment and this will necessitate that core facilities be sited in specific locations.

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<sup>4</sup> Environmental genomics requires a range of particular analysis approaches (e.g. . . . . meta transcriptomes, barcoding)

<sup>5</sup> e.g. Annotation marathons; in-house training; advanced residential practical and theoretical workshop series; EMBO workshops, ASSEMBLE workshops; Masters courses

<sup>6</sup> Acknowledging that considerable capability for biochemical purification is available through commercial and other organizations and that many analytical facilities (e.g. isotope analysis) do not need to be specifically marine

<sup>7</sup> e.g. RNAi libraries, the ability to generate and test libraries for transgenic approaches might be helpful to boost the development of individual model species, e.g. genome/transcriptome wide RNAi libraries or TALENs.

- **Communications and technology transfer:**
  - i. As part of a communications strategy, 'omics developments within EMBRC should be underpinned by appropriate links and partnerships within and beyond the EMBRC.
  - ii. As a matter of urgency, The EMBRC 'omics community should establish dialogue with national funding bodies to set priorities for marine 'omics infrastructures and programmes in the marine sciences through national roadmaps and strategic priorities.
  - iii. Develop agreements with major sequencing centres and marine 'omics-relevant organisations that facilitate access for 'omics projects (e.g. Sanger, Illumina Centre, Tara Oceans, Norwich, JGI, Genoscope, Genome Standards Consortium).
  - iv. Establish and maintain strong links with the developing e-infrastructure.
  - v. Improve communications, with other ESFRI infrastructures that have relevant 'omics strategies (ELIXIR, EuroBioImaging), for example through reciprocal attendance at workshops.
  - vi. At the European level, establish close dialogue with the Innovation strategy of EuroMarine as well as with other FP7 programmes (e.g. Marine Genomics for Users (MG4U)) for knowledge transfer between partners and potential users.
  - vii. Communication with the technology translation departments of all ppEMBRC partners needs to be established to ensure seamless service provision.

## 5.4. Mobility of Researchers and Users Access

### 5.4.1. Strategic drivers

The need to access diverse marine organisms for research has stimulated construction of marine biological research centres around the European coast for more than 125 years. These have developed, largely independently, into world-class facilities. Taken together, these centres represent a critical mass of infrastructure and human resources that have a significant influence on marine research. To optimise the provision of service to in the life sciences to the European research community, the distributed and national marine centres have developed international cooperation strategies.

Networks of Excellence, notably Marine Genomics Europe, MarBEF and Euroceans have paved the way for 13 infrastructures, such as ASSEMBLE, set up to enhance trans-national access to existing key infrastructures for marine sciences and the provision of marine model organisms. By fostering user access EMBRC is the logical follow-up of ASSEMBLE. However, EMBRC will go significantly further in improving the entire research infrastructure and service provision to facilitate user access from across Europe and by opening the

research infrastructures to users outside academia and the life sciences, profoundly developing the ERA.

EMBRC will inherit the experience and procedures in place with ASSEMBLE and will need to effectively adapt, expand and up-date them to suit EMBRC needs to ensure immediate implementation and efficient management by the EMBRC partnership from the beginning.

#### 5.4.2. Strategy recommendations

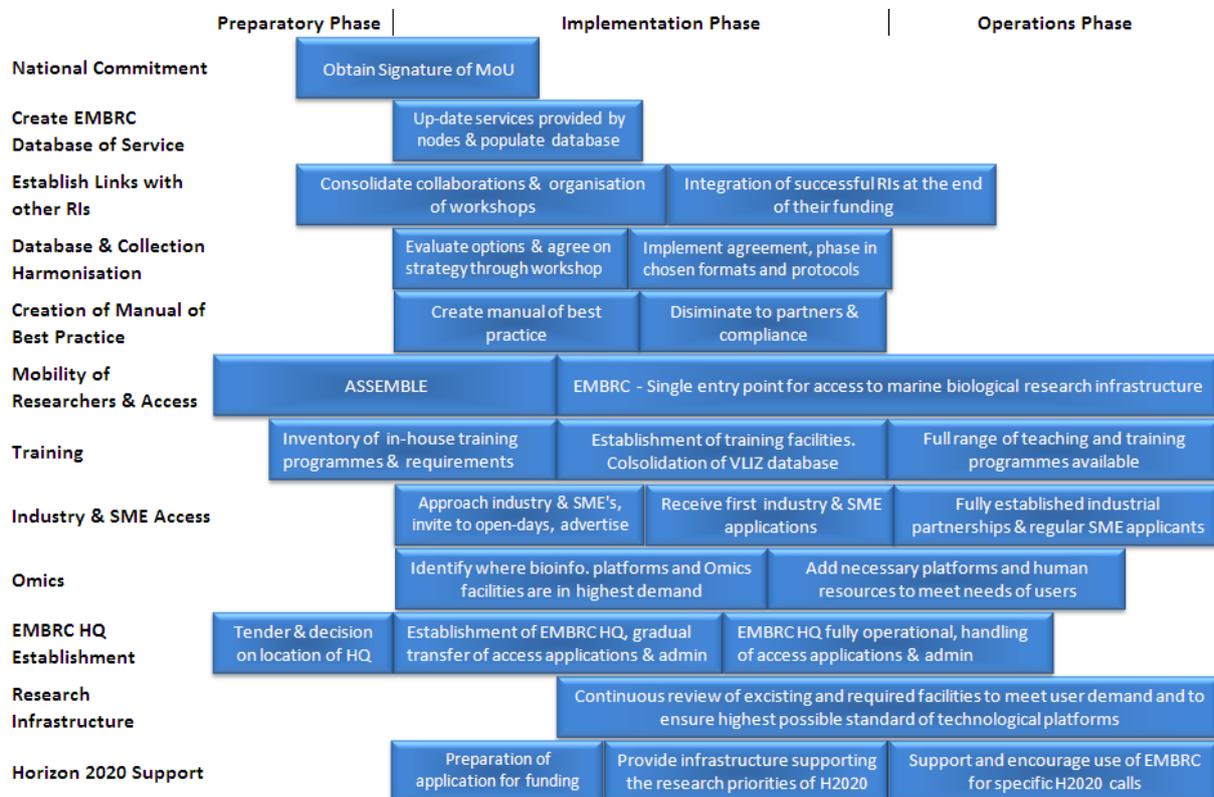
- **On-line application system: a single entry point for users and administrators.** A single entry point for users and administrators should be used to coordinate and optimise information, application systems and access mechanisms for both remote and/or on-site access. The online system will be administered by the EMBRC Core Office who will coordinate the evaluation of applications. Administrative centralization will minimise application processing times and increase the number of visits possible to EMBRC infrastructures.

Using this online system, users can apply for access to various infrastructure types and platforms available at partner institutes (laboratories, research vessels, field stations, field sites, etc), report achievements, confirm the amount of access delivered, and report publications and outputs resulting from each type of access. Details of how access to EMBRC infrastructures and services could be achieved in a uniform and user-friendly way were developed and published in the reports D10.2. "*Best practise guidelines for uniform assess to institutions and research platforms*" and D10.3. "*Outline for the preparation and submission of user proposals*".

- **On-site liaisons officers.** Guests to EMBRC facilities should be supported by local contact persons. Local experts may give advice on experimental design in relation to the local environment, but also supply support with facilitating local permits for sampling and experimental procedures. These liaisons officers should be appointed during the implementation phase and should either be members of staff or a person fully employed by EMBRC at the station. The on-site liaison officer will also be the direct contact link between the EMBRC core and the nodes for reporting, updating and implementation of EMBRC strategy (e.g. D2.4 *Recommendations for recurrent scientific and technological review system*).
- **Continuous improvement and harmonisation.** It is recommended that EMBRC organises advanced training and workshops mainly for technical and administrative staff to harmonise techniques and services related to on-site access, remote access, animal transportation and handling of organisms and samples. The outcomes of such workshops should be included in EMBRC technical reports to be shared widely amongst nodes and visitors.
- **Outreach and advertisement.** In order to provide a fast and effective over-view of available services it is important that EMBRC advertise and list the services and types of access provided at each node. This will be accessible on the EMBRC website, along with

the EMBRC service database (see WG1 strategy paper “Establishing an EMBRC Service Database”). Summaries of approved projects will also be available through the website allowing potential applicants to gain an overview of the potential of EMBRC. Descriptions of the terms and conditions of access should be accessible online (see report D10.1). Finally, as part of the advertisement and promotion it should be highlighted that users may apply for access and multiple stations in an application, whether this be for using different platforms and facilities or for accessing and/or sample collection of multiple sites/habitats.

- Learning from the ASSEMBLE experience?** A workshop will be required early in the implementation phase to brief EMBRC partners about selection and procedures and to enable ASSEMBLE partners to pass on their proof of concept experience. This will be an opportunity, to gain insight into how an access system works and how to manage more frequent, short-term visitors.



**Figure 1:** The major strategic priorities and their evolution over implementation and operations phases.

## 6. Technology and Knowledge Transfer (KTT)

EMBRC will be included in a platform for knowledge transfer that can reach out to scientists as well as to government and industry. The methodology for the EMBRC KTT service will follow that developed by several EMBRC partners in the CSA “Marine Genomics for Users” (MG4U) (KBBE.2010.3.2-02), whereby visitors will be asked to spend 10-15 minutes with the

EMBRC node officer before the end of their visit to fill out a questionnaire regarding their research and potential application (questionnaire developed by MG4U). Questionnaires are added to the EMBRC knowledge transfer database which is accessible by all EMBRC nodes for KTT purposes. This tool will allow users to find exactly what is relevant to them in their innovation strategy. In relation with the promotion of EMBRC, other dissemination media will be developed, including attendance to specialised business conventions and participation to genomic observatories. This activity led by the Central Office will markedly enhance intellectual property brokerage for the EMBRC and increase EMBRC economic impact.

## 7. Joint Development Activities

Unparalleled developments in high throughput, analytical molecular and culturing technologies, along with improved access to ecosystems and organisms will see a dramatic increase in the demand for access to species that are currently not well understood over the next 10-20 years as 'omics technologies open up new opportunities beyond the current limited number of model species. In parallel, cutting-edge analytical technologies will continue to develop at an exponential rate. The provision of marine biological resources and in-house analytical platforms specialized for marine biological research are the most distinctive and emblematic services of the EMBRC infrastructure and the EMBRC consortium has a mission to strive to constantly improve the quality and range of these services.

The JDAs will be highly instrumental in integrating the partners of EMBRC into a coherent distributed international research infrastructure offering high quality services to diverse user communities. Where appropriate, they will be conducted in close consultation with complementary infrastructures (e.g. ELIXIR, MIRRI, AquaExcel, Lifewatch) in order to cross-fertilize best practises and avoid unnecessary duplication of effort. The R&D program will focus on improving existing services as well as developing new services in anticipation of demand to respond to scientific and biotechnological research priorities of academic, governmental and industrial users in response to emerging societal challenges.

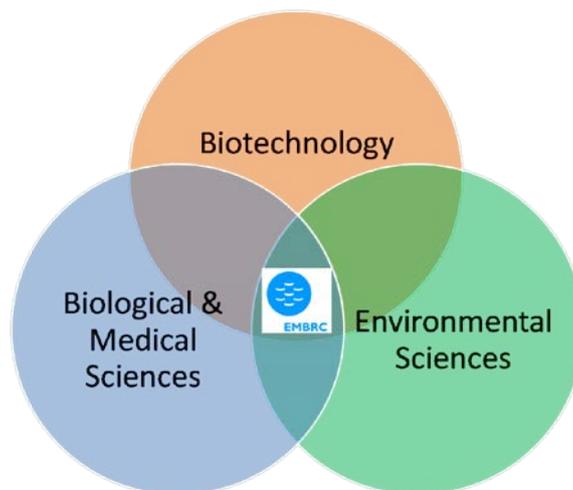
This will be achieved via a coordinated, long-term R&D program involving collaboration between all EMBRC partners, designed to:

- i. Facilitate high-priority technological and methodological breakthroughs for the collection, long-term *ex situ* maintenance and transport of live unicellular and multicellular marine organisms and for development of culture facilities capable of better simulating natural environments;
- ii. Create genetic resources such as mutant collections and transgenic lines for flagship eukaryotic and prokaryotic model organisms;
- iii. Adapt and develop 'omics and related methods for high throughput environmental biodiversity studies and functional exploration of marine models;
- iv. Develop the transversal e-infrastructure component of EMBRC that will be critical both as a means of managing the resources and as a major tool to facilitate exploitation of the resources.

- v. Develop new models with high ecological relevance (e.g. representing key functions in the ecosystem) along with the tools needed for advanced research including permanent cultures of ecotypes and inbred lines, full genome sequence information, genetic tools for functional genomics, pipelines for phenotypic characterization, and a database providing access to relevant genetic and ecological data.

## 8. Cementing EMBRC in the strategic research landscape in Europe

EMBRC is a member of the Health & Food ESFRI research infrastructure group, strategically positioned to provide basic research and discovery for translation and application in the biomedical and biotechnological domains. In parallel, marine biological research has strong connections to the Environmental ESFRI research infrastructure group through research in ecology and interdisciplinary research integrating biology and oceanography. **Consequently EMBRC is well positioned to provide a bridge between environmental, biomedical and biotechnological research.**



**Fig. 2: EMBRC central position** within the strategic research landscape, where services are extendable to biomedical sciences, environmental sciences and the biotechnology sector. These services cover both public and private sectors.

A number of ESFRI Research Infrastructures are currently fully operational or entering various stages of operation. EMBRC will work to avoid duplication of efforts, and will ensure that facility sharing opportunities are maximised between infrastructures. The following projects and initiatives are of particular relevance and importance to EMBRC.

## 8.1. The importance of links with other ESFRI RIs

### ESFRI Health & Food RIs:

- EATRIS is a research infrastructure specialising in translating discovery into new preventive, diagnostic and therapeutic strategies in medical sciences. This RI provides a potential vital link for bringing discovery and basic research done in EMBRC out to the medical community.
- ECRIN is a clinical research infrastructure aimed at providing access for investigator-driven clinical research in Europe. The network allows for access to multi-national clinical research, an essential component for bringing novel products to the market. This will provide the much needed component for bring EMBRC discovery to the next level.
- ELIXIR is established to provide the infrastructure for collection and distribution of large biological datasets in Europe. It is essential that EMBRC integrates and communicates with ELIXIR to follow and implement the standards and initiatives put forward to ensure compatibility and the long-term security of EMBRC-generated data.
- EU-OPENSREEN will provide platforms to screen biomolecules in order to identify new target classes of bioactive compounds for commercial development.
- EUROBIOIMAGING will provide a distributed biological and biomedical imaging infrastructure. EUROBIOIMAGING has a focus on establishing access and training, as well as sharing of best practices and image data, and thus provides an excellent opportunity for collaboration with EMBRC. While imaging facilities will be a major resource provided for EMBRC users within marine centres, EMBRC will seek to establish links with EUROBIOIMAGING to provide training in advanced imaging and to gain access to large scale and specialist imaging facilities that are beyond the capability of marine centres.
- INSTRUMENT provides access to structural biology facilities and represents a potential partner in joint research programmes for drug discovery from the marine environment.
- MIRRI is a distributed research infrastructure providing micro-organism services facilitating access to more than 350,000 high quality strains, their derivatives and associated data for research, development and application. Due to potential overlap in supplies of organisms and related services it would be beneficial to both MIRRI and EMBRC to collaborate on organism provision, as well as sharing of culture expertise.

### ESFRI ENVIRONMENT RIs:

- LIFEWATCH: will provide electronic services and virtual laboratories for biodiversity research. There are significant opportunities for joint initiatives in provision of bioinformatics, data integration and interoperability, and training links for EMBRC users.
- EMSO: will provide a network of cabled sea-floor observatories for research into areas such as geosciences, oceanography and biology. EMSO will provide access to monitoring platforms in the deep-sea, and throughout European waters, and crucial time-series data that feed into the historical datasets held within EMBRC. Good ties

will also need to be established between these two projects to allow for cross-disciplinary projects that will benefit from both infrastructures.

## 8.2. Other RIs: (I3 infrastructures)

- MESOAQUA provides transnational access to mesocosms from the Arctic to the Mediterranean and includes two ppEMBRC partners. MESOAQUA is set to become the leading provider in mesocosm access.
- AQUAEXCEL is in the preparatory phase and aims to provide access to state-of-the-art facilities and technology to advance European aquaculture. This is a highly specialised RI and is likely to have some overlap with EMBRC.
- EUROFLEETS is providing access to Europe's largest ocean-going research vessels. Collaboration with this project would allow for joint proposals with EMBRC involving ocean cruises across the globe with state-of-the-art research, culturing and aquaria.

A workshop exploring collaboration between ESFRI RIs and other EU projects took place in May 2013 (full details can be found in "Marine and biological sciences infrastructures interaction and collaboration workshop: *complementarity and synergies between facilities and infrastructure initiatives*" workshop report). This meeting highlighted the following areas for further exploration to enhance co-operation between projects:

- Mutualising access through use of similar access applications between RIs; possibility of transferring access applications between RIs; enabling co-applications and synchronisation of access calls.
- Training: Sharing information about training courses within the RI community will facilitate dissemination of knowledge between research communities and stimulate multidisciplinary as well as avoiding duplication, ensuring wider target audiences and sharing of resources.
- e-Infrastructure: Due to the many initiatives involved with data management, handling and management, co-ordination of e-infrastructure between RIs is of key importance. EMBRC must keep abreast of developments in e-infrastructure and ensure compliance and engagement with relevant initiatives, in particular ELIXIR.
- Innovation – from research to products and services: collaboration in promotion and marketing of the RI community, adaptation of similar knowledge exchange procedures, similar intellectual property (IP) policies, and combining services for industry and the private sector are all areas where a combined approach will be beneficial.

The workshop only allowed for the general exploration of these topics. It is recommended that EMBRC follows up on these issues during ipEMBRC to continue to build the RI community and emerge as one of the driving forces. Separate workshops are required to deal with each of the strategic areas mentioned above and should be organised during the first two years of ipEMBRC to ensure that workshop outcomes can be implemented before opEMBRC.

As these RIs (e.g. AQUAEXCEL, MESOAQUA) are limited in funding and duration, EMBRC should seek to establish collaboration with these projects. The highly specialised nature of these RIs means they offer either different or more advanced services. If these projects prove to have high demand EMBRC may consider taking on a few key institutes from these RIs to compliment the services and facilities already delivered by EMBRC.

### 8.3. EU Initiatives and Consortia

- **BioMedBridges:** This initiative is building e-infrastructure for the Health & Food RIs and plays a crucial role in their organisation. This project has a strong medical/patient focus and is thus likely to be very influential in lobbying for funding at national and EU levels. Continued participation and strong enthusiasm are necessary to stay involved here and make new opportunities for collaboration and funding from the medical sector.
- **EUROMARINE:** EUROMARINE is the integration of three former Networks of Excellence – EUR-OCEANS, MarBEF and Marine Genomics Europe. It is a major driver of European marine biological research strategy. EUROMARINE will integrate closely with EMBRC for provision of facilities for research delivery. Communication is already established between EMBRC and EUROMARINE to identify infrastructure platforms of strategic importance. It is recommended that a EUROMARINE representative be appointed to the EMBRC Reference User Group (RUG).
- **MG4U (Marine Genomics for Users)** aims to facilitate knowledge transfer between genomics and industry. MG4U will provide training opportunities, know-how and information to industrial users with interests in genomics. MG4U is planned to continue until mid-2013, after which the services provided by this initiative should be absorbed into EMBRC to ensure continuation.
- **Joint Programming Initiatives (JPIs):** The overall aim of the Joint Programming process is to pool national research efforts in order to make better use of Europe's public R&D resources and to tackle common European challenges more effectively in a few key areas. It is a structured and strategic process whereby Member States agree, on a voluntary basis and in a partnership approach, on common visions and Strategic Research Agendas (SRA) to address major societal challenges.
- **ERA-NETS:** In contrast to JPI, ERA-NETS are a dedicated funding instrument under H2020 to coordinate national/regional programmes. The objective of the ERA-NET scheme is to step up the cooperation and coordination of research activities carried out at national or regional level in the Member States and Associated States through the networking of research activities and the mutual opening of national and regional research programmes.

EMBRC must work to establish strong ties with initiatives and consortia. They all play vital roles in directing marine science, funding and knowledge exchange. Creating strong ties with these will ensure the long-term future of EMBRC as a strong player in shaping marine

science in Europe, and will also provide the services and facilities necessary to carry out strategic research of national and international importance.

## 9. Engaging with Industry and the Private Sector

Linking public-sector research to the private sector and industrial R&D is a vital component in the Innovation Union and for funding under H2020 and is likewise hugely important to EMBRC. However, while certain marine centres have established strong working links with industry, several others have limited experience in this area. A clear strategy that sets out how links with industry will be fostered and optimised is urgently required early during ipEMBRC.

During ipEMBRC the first task will be to locate and engage with potential industrial and private sector interest groups (e.g. BioMarine, Biosciences Knowledge Transfer Network) to enhance the visibility of EMBRC. At the same time the individual EMBRC nodes should operate a national, regional and local levels to engage potential industrial partners

Opening lines of communications with this new user group should take the shape of providing regular up-dates on ipEMBRC progress, invitations to participate in open days where facilities and technology can be show-cased, and fora to engage with local nodes to gauge whether their facilities and services can meet the needs of private sector users. Ultimately this ground work will be fed back to the Promotion, Communication, Marketing & Outreach Officer (PCMOO) at the EMBRC Core Office. The positive engagement with this user community will have a major impact on the financing of local nodes under H2020. Being able to demonstrate strong socioeconomic benefits as well as collaborative projects with the private sector will provide a strong case for securing RDF support for EMBRC development as well as investment grants for research projects with private sector partners.

## 10. Meeting Future Research Needs: Horizon 2020

### 10.1. Horizon 2020

Horizon 2020 is the new European Union funding programme that succeeds Framework Programme 7.

Horizon 2020 outlines six priority areas for research funding:

- Health, demographic change and wellbeing
- Food security, sustainable agriculture, marine and maritime research and the bio-economy
- Secure, clean and efficient energy
- Smart, green and integrated transport

- Climate action, resource efficiency and raw materials
- Inclusive, innovative and secure societies

It is expected that EMBRC will provide a major component of the infrastructure required to address the research priorities of Horizon 2020 in the marine sciences. The key thematic research areas identified by ppEMBRC (D2.1 Report on Key Thematic Areas) cover these areas of prioritisation with ppEMBRC partners being particularly strong in the areas of food security, aquaculture, bio-fuel and energy and climate research, resource efficiency and raw materials. In order to extend research and collaboration to the biomedical sector EMBRC partners will have to develop competencies within the food and health sectors as well.

Horizon 2020 aims to raise the level of excellence in Europe's science base and ensure world-class research to secure Europe's long-term competitiveness. It will support the best ideas, develop talent, provide researchers with access to priority research infrastructure, including e-infrastructure and make Europe an attractive location for the world's best researchers. In providing a mechanism for European-wide access to the most advanced facilities for biological sciences, EMBRC will represent a key element of this strategy within the marine sciences.

With an outreach programme already engaging SME and biotechnology companies, EMBRC is set to support the Industrial Leadership campaign of Horizon 2020. By making highly specialised facilities, technology transfer services (i.e. MG4U), training and know-how available to the industrial sector SMEs will be able to push their research and development further without prohibitive investment costs associated with capital infrastructure. By offering facilities for research, training in the newest techniques and equipment, and innovation EMBRC represents an excellent collaborator for the European Institute of Innovation and Technology (EIT), a major partner and driver in Horizon 2020. Moreover, EMBRC will be an excellent tool for disseminating expertise and knowledge within Europe.

Altogether, EMBRC will play a key role in raising the standards and ensuring that Europe continues to be a competitive and attractive region for marine biological research.

## 10.2. Horizon 2020 and funding

H2020 will also play a crucial part in the successful running of EMBRC. ESFRI RIs are eligible for H2020 funding to support implementation, long-term sustainability and operations. Specifically, under H2020 call 4.1.1 Developing New World-Class Research Infrastructures EU funding will support:

- i. The **implementation phase** (e.g. R&D and engineering work, development of regional partner facilities, etc.)
- ii. The **operation phase** (e.g. access, data handling, outreach, training and international cooperation activities)

Structural funds will also become available to RIs under H2020. One of the objectives of ERDF funding is the strengthening of research, technological development and innovation, with an investment priority of “Enhancing research and innovation infrastructure (R&I) and

capacities to develop R&I excellence and promoting centres of competence, in particular those of European interest” (ERDF, Art. 5.1.a).

## 11. Acknowledgment

The WP2 Coordinator Colin Brownlee and Officer Nicolas Pade would like to thank the following people for their input and support in putting this report together:

**SZN:** Wiebe KOOISTRA, Sandra FERNANDES, Maurizio RIBERA D'ALCALA, Paola CIRINO, Ina ARNONE, Euan R. BROWN, Giovanna Benvenuto;

**UGOT:** Michael THORNDYKE, Niklas ANDERSSON;

**SBR:** Laurent LEVEQUE, Nathalie SIMON, Xavier BAILLY, Ian PROBERT, Cathrine BOYEN, Anne-Emmanuelle KERVELLA, Cécile CABRESIN, Gaëlle PENAULT, Bernard KLOAREG, Isabelle PALLARD;

**OOB:** Pascal ROMANS, Francois-Yves BOUGET, Marcelino SUZUKI, Virginie BOUTEL, Philippe LEBARON;

**OOV:** Fauzi MANTOURA, Larnet GILETTA, Antoine SCIANDRA, Gaby GORSKY, Evelyn HOULISTON;

**SAMS:** Ken JONES, Kim LAST, Martin SAYER, John DAY, Claire GACHON;

**USTAN:** Anne MAGURRAN, Ian JOHNSTON, Huanting LIU;

**MBA:** Claudia CASTELLINI, Rowena STERN; Judith FUCHS

**CCMAR:** Karim ERZINI, Deborah POWER, Gareth PEARSON, Adelino CANÁRIO;

**AWI:** Angela SOMMER, Hans PÖRTNER;

**HCMR:** Paraskevi POLYMENAKOU, Christos ARVANITIDIS, Vivi PITTA, Giorgos KOTOULAS, Evangelos PAFILIS;

**SARS:** Fabien RENTZSCH;

**EMBL:** Detlev ARENDT, Chuck COOK.