



EMBRC
EUROPEAN
MARINE
BIOLOGICAL
RESOURCE
CENTRE

Report on Key Thematic Areas

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The EMBRC preparatory-phase



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1. Introduction

Work Package 2 of ppEMBRC has been charged with the planning of top-quality research services and strategic work. As a first task this work package has been asked to identify key scientific and technological themes relevant to EMBRC functioning and to evaluate existing capacities within these thematic areas.

This report was informed by a questionnaire distributed to each of the participating partners in ppEMBRC, soliciting information on:

1. Current relevant research topics/themes investigated by the partners
2. Relevant major infrastructure and facilities which could potentially be committed to EMBRC
3. Institution and national research drivers potentially relevant to EMBRC strategy
4. Infrastructure requirements beyond existing capacity
5. Expression of interest in participation and composition of future working groups

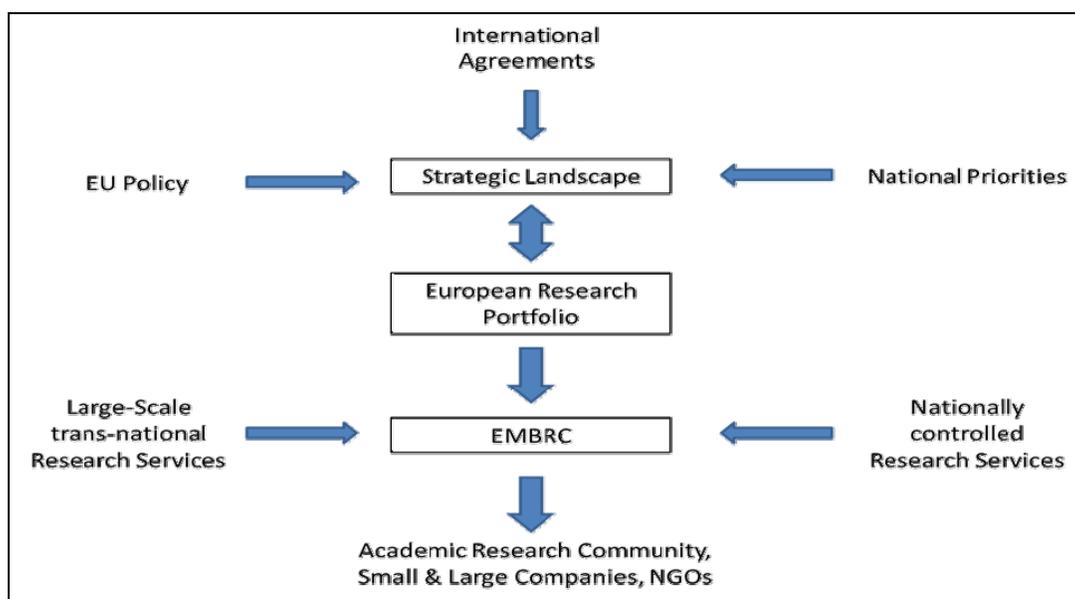


Figure 1: The EMBRC will provide a single point of entry to research infrastructure in marine biology (trans-national facilities and agreed sharing of nationally controlled services) to enable European researchers to compete at the highest international level in support of national and European strategic scientific objectives.

This document presents an initial investigation of the strategic landscape and policy drivers, underpinning research themes relevant to the EMBRC and the necessary research services, as well as mapping analysis of service provision by theme and institution. The outcome of this process is a “straw-man” document for the future EMBRC scientific strategy for discussion by the Steering Committee and WP2 thematic working groups. A proposal is also made for the number and types of working group required.

2. Strategic Landscape and Policy Drivers

The following policy drivers have been identified as being of national and pan-European importance, based on documents in the public domain (Annex I).

- **Sustainable Marine Resource Management:** The key aspects of this driver deal with the importance of sustainable management of all our marine resources, including fisheries, energy (oil and gas, renewables such as tidal, wave and wind power), shipping, invasive and introduced species, leisure activities, dredging, mining, and pollution, marine conservation zones and marine protected areas.
- **Health of the Human Population:** The marine environment is of increasing importance in human health because of the adoption of marine models in basic biomedical research (e.g. sea squirt, amphioxus), drug discovery, development of diagnostic tools, and the potential of viral transmission from animal species to humans (e.g. cholera, avian flu, seal adenovirus epizootics).
- **Biodiversity:** The importance of healthy seas for human well-being is widely recognised because of the important role of the oceans in climate control and regulation, as well as providing a vital source of human nutrition through capture fisheries and aquaculture. Biodiversity is also of key relevance in the development of the biotechnology sector as biological understanding is transferred into industrial application, product development and new technology.
- **Food security:** This driver includes sustainable protein production from marine sources, exploitation of new species (algae, invertebrates, fish), the replacement of fish oil and protein in aquaculture feeds with locally sourced plant and algal products, improved aquaculture production with reduced environmental impacts, and the traceability of marine food stuffs from sea to plate.
- **Climate change:** Understanding impacts of, adaptations to and mitigation against effects of climate change (ocean warming, ocean acidification, circulation changes and nutrient availability) is a key component of a number of National and European marine strategies. This requires better understanding of organismal and population biology and the identification and study of key indicator species and communities. As the marine environment is also a major carbon sink, for example through

photosynthesis by phytoplankton, it is important to further research ocean ecosystem function and dynamics to understand their importance in reducing carbon emissions.

3. Research Themes

These are the research themes that have been identified as currently being supported by EMBRC partners which are considered to be important for national and pan-European strategic research priorities in marine biology. Outlined below are the key research topics currently investigated within the ppEMBRC partners:

1. Biodiversity and Ecosystem Function

EMBRC currently exploits the dramatic increase in tools available for integrative investigations of marine systems at all levels of organisation from molecular to ecosystem. For example, genetic diversity and adaptation of populations can be studied at the level of individual genomes and metagenomic approaches allow the exploration of microbial diversity of hitherto unculturable organisms. Studies of chemical ecology enable molecular signalling mechanisms to be elucidated and their role in environmental adaptation determined. Other research priorities include investigation of oceanic patterns of trophic exchange, foraging and diving behaviour, population diversity and dynamics and animal migration (e.g. spatial ecology of plankton and predators), as well as impact of invasive and toxic species and the role of viruses in ecosystem functioning. Molecular analysis combined with classical taxonomy studies are being utilised to extract additional value from time-series of ecosystems. This theme also provides an ecosystem context for model organisms.

2. Developmental Biology and Evolution

Marine organisms provide a rich resource of models for deeper understanding of fundamental biological processes and will continue to underpin major advances in evolutionary and developmental biology. In particular marine embryos and life stages allow studies of the evolution of gene function during development. Research in this area include tractable marine models for fundamental research on the cellular, molecular, genetic and physiological basis of developmental processes and their evolution, for example, the use of echinoderm eggs to understand the early molecular events accompanying fertilisation. Marine models also allow the study of underlying mechanisms of development and evolution, for example the roles of non-coding DNA sequences, regulatory RNAs and epigenetic mechanisms, how they evolve, and their function in development and disease. Other priorities currently investigated within this theme include genomic approaches to the

evolution of bio-mineralisation in marine flora and fauna and the co-evolution of organisms and the biosphere.

3. Biogeochemistry and Global Change

The focus of the EMBRC within this theme is on organismal interaction with biogeochemical cycles in the sea and ocean atmosphere exchange. Priorities include carbon and energy cycles, feedbacks among biologically uptaken metal cycles and carbon chemistry and coupling between different oceanic realms. Studies on diversity, adaptation and function of organisms and ecosystems in response to global change factors are underway for predicting future climate scenarios and developing mitigation strategies. In this context the use of natural models in ocean processes can be valuable, for example, CO₂ vents to investigate natural acidification impacts on ecosystem biodiversity.

4. Marine Products and Resources

The marine environment presents vast and underutilised potential for development of natural products (Biotechnology). Sustainable use of this resource requires sophisticated knowledge of the interactions of marine species with human activity. EMBRC partners are for example studying the impact of oil and gas extraction platforms, tidal and wind power structures with animal migration and habitat utilisation. Genomic approaches and life cycles of organisms are being explored to improve aquaculture production, for example in the development of sustainable feeds and marker-assisted selection of superior strains for farming. The mining of marine genomes is underway to develop new industrial products and processes (for example the identification of favourable microalgal strains for biofuels, secondary and refined products). Research on marine pollution and ecotoxicology is also being carried out, for example understanding of detoxification mechanisms, for treatment of contaminated environments.

5. Biomedical Science

Fundamental studies on physiology and behaviour are currently underway on a number of research topics, including simple nervous systems, neural networks, developmental physiology and locomotion. With the demand for new treatments and diagnostic tools, as well as a deeper understanding of various medical conditions being required, studies on marine organisms will provide fundamental insight into biomedicine, particularly with respect to infection, immunity and disease (e.g. sponges and symbiotic bacteria, polychaetes resistant to pathogenic bacteria and producing hydrolytic enzymes, extremophiles, algae and their symbionts, cyanophages). Marine models for studying DNA replication, repair and gene

transfer and structure-orientated drug design are also of key importance in EMBRC research and are being developed further.

4. Research Services

The large scale services in existence for supporting cutting-edge research in the above themes are summarized here, as well as the mapping of services to the research themes (Fig. 2) and services to partner capacity (Fig. 3):

- **Models Species, Culture Collections and Databases: (MCD)**

Research services under this heading include the curation of species with sequenced genomes (wild-type reference populations and mutant strains) and the development of tractable new model species for which varying degrees of genomic resources are available (e.g. from limited sequencing information to complete transcriptomes, end-sequenced BAC libraries and genetic linkage maps) (Annex 2). Further facilities include national culture collections and identification capabilities for algae, protozoans and plankton, National and international databases of genomic resources and marine biological information. The requirement to integrate these various databases to extract further value for the marine community is being undertaken in WVP3.

- **Aquaria and experimental facilities (in-house and remote stations) including hosting facilities: (AE & H)**

Research services under this heading include open-circulating seawater and freshwater aquaria systems, re-circulating and environmentally controlled aquaria (temperature, light, pH, gases), laboratory scale and field-site mesocosms, flumes, hyperbaric units and licensed large-animal holding and experimental facilities, specialised containment facilities for genetically modified organisms. Diving facilities for scientific purposes (e.g. specimen collection, survey etc) hyperbaric units and pressure related research facilities. Allied support facilities include service laboratories for visiting scientists and hotel facilities (private and in-house).

- **Research Vessels and Mobile Platforms: (RV)**

Dedicated Research vessels equipped for biological, geological, geophysical, glaciological, and chemical research, including ice-strengthened vessels for polar research. Container-borne laboratories and animal transport facilities are also available. Other facilities available include a variety of inshore boats for specialist sampling, animal capture and diving platforms. There are also remotely operated, semi-autonomous and towed platforms.

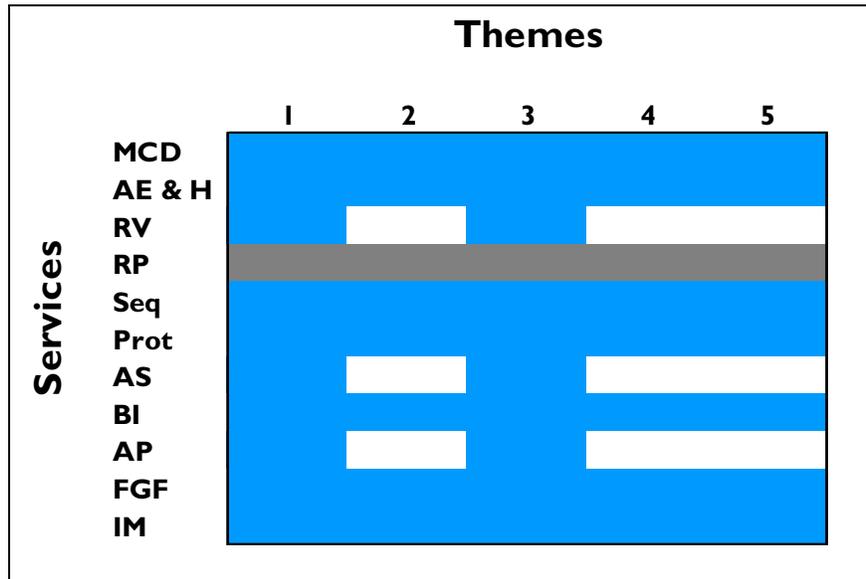


Figure 2: Mapping of research services provided by EMBRC to identified key research.

- **Research Platforms: (RP)**

- *High-Throughput Sequencing (Seq):* Next generation sequencing platforms (e.g. Roche 454, Solexa Illumina, ABI Solid), oligonucleotide and spotted C-DNA micro-array platforms.
- *Protein Structure Determination (Prot):* Robotic, cloning, protein expression, protein purification and crystallisation facilities; X-ray diffraction facilities for protein crystallography; Mass-spectrometry (e.g. Applied Biosystems Q-Star MS/MS, Micromass MALDI-TOF and LCT, LC ESI-MS/MS); Nuclear Magnetic Resonance Spectroscopy (NMRS); Circular Dichroism Spectropolarimeter (CDS), Isothermal Titration Calorimeter (ITC), Electron Paramagnetic Resonance Spectrometers (EPRS).
- *Analytical Services (AS):* Gas Source Ratio Mass spectrometer, Atomic Absorption Mass Spectrometer.
- *Bioinformatics (BI):* Next-generation sequence assembly, SNP discovery, microsatellite isolation, RNA-seq, RAD-sequencing, sequence annotation, tree construction, evolutionary analysis.
- *Animal-borne and Animal Monitoring Platforms (AP):* Facilities for design and manufacture of ultra-low energy data loggers and relay systems (e.g. satellite-linked and GSM mobile phone); sensors for measuring acceleration (3D),

temperature, depth, light level and physiological performance; development and fabrication of benthic instrument landers for long-term animal monitoring; development and implementation of software for visualization and statistical analysis of movement data.

- *Functional Genomics Facilities (FGF)*: Facilities for the sterile culture of primary and transformed cell-lines, RNA-i, over-expression, and other *in vitro* functional genomic techniques. Micro-injection systems for the production of trans-genes and *in vivo* functional genomic analysis. Cell physiology, including electrophysiology.
- *Imaging (IM)*: Scanning and transmission electron microscopes, fluorescence microscopy, laser scanning confocal microscopy, multiphoton and ultra-high resolution microscopy (including video and high-speed imaging), light microscopy (interference, polarization, DIC), flow cytometry and cell sorting, NMR imaging.

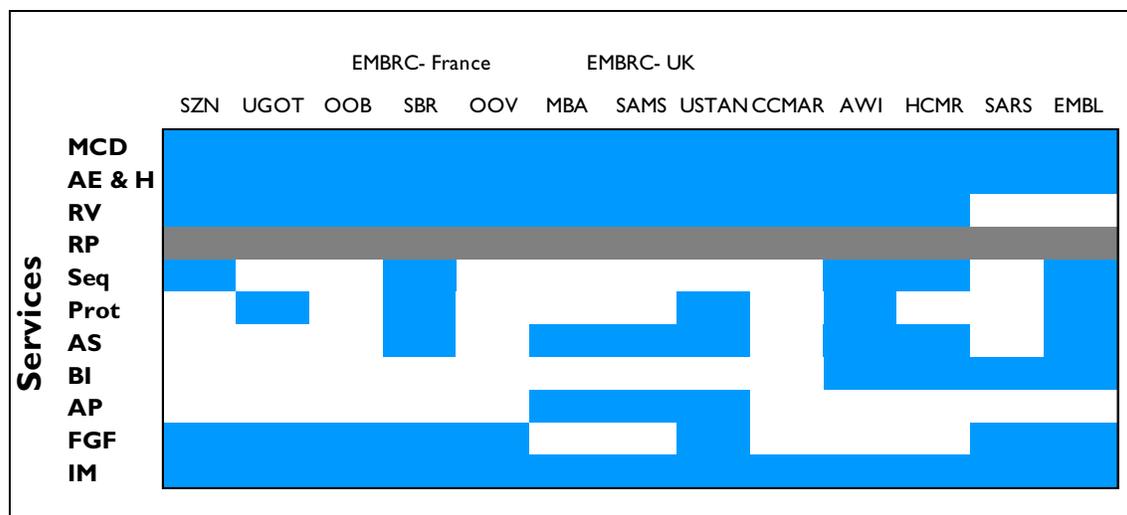


Figure 3: Mapping of large-scale partner capacity onto research services required by EMBRC.

5. Consideration for Future Capacity

- Is there currently sufficient laboratory space, hosting facilities and technical support for visiting scientists and training purposes?
- Is there a requirement for additional sequencing capacity dedicated to the marine community? If so, should any further capacity be centralized or distributed amongst multiple nodes?

- In areas of rapid developing technology, for example, sequencing and structural proteomics, how should the up-dating of equipment be handled within EMBRC?
- The requirement for metabolomics facilities and expertise within the EMBRC?
- Co-ordination with WP3 (e-infrastructure)

6. Proposal for the formation of standing working groups

The following recommendations are made for the formation of standing working groups to continuously monitor and up-date the research themes and facility requirements identified at the out-set of ppEMBRC:

- Aquaria and Culture (husbandry, holding, culture and experimental facilities)
- Access to Ecosystems (ecosystems, infrastructure & sampling, research vessels & mobile platforms)
- ‘Omics Technologies (Genomics, Structural Biology, Functional Genomics):
- Trainings & Standards

ANNEX I

- AVISAN-ITMO “biologie cellulaire, développement et *evolution*” policy (<http://www.aviesan.fr/fr/aviesan/accueil/menu-header/instituts-thematiques-multi-organismes/biologie-cellulaire-developpement-et-evolution>)
- EU Marine Strategy Framework Directive
- <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF>
- European Commission Communication *Our life insurance, our natural capital: an EU biodiversity strategy to 2020* (http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5B1%5D.pdf)
- European Science Foundation Marine Board: Position Paper 15: *Marine Biotechnology; A New Vision and Strategy for Europe*. (http://www.esf.org/index.php?elD=tx_nawsecuredl&u=0&file=fileadmin/be_user/research_areas/marine/pdf/Publications/MBPP15MarineBiotechnology.pdf)
- Marine Climate Change Impacts Annual Report Card 2011-2011 ([http://www.mccip.org.uk/annual-report-card/2010-2011/pdf-version-\(377-mb\).aspx](http://www.mccip.org.uk/annual-report-card/2010-2011/pdf-version-(377-mb).aspx))
- Marine Genomics Europe Final Activity Report (<http://www.marine-genomics-europe.org>)
- Next Generation Science for Planet Earth 2007-2012: Natural Environment Research Council Scientific Research Strategy: (<http://www.nerc.ac.uk/publications/strategicplan/documents/strategy07.pdf>)
- Ocean Genome Resource Policy document
 - http://www.ogf.org/OGR_collection_policy.pdf
- Scotland's Seas: Towards Understanding their State (<http://www.scotland.gov.uk/Publications/2008/04/03093608/0>)
- UK Marine Science Strategy (<http://archive.defra.gov.uk/environment/marine/documents/science/mscc/mscc-strategy.pdf>)
- Université Pierre & Marie Curie “André Picard Network” Scientific Initiative (http://www.upmc.fr/fr/recherche/pole_4/reseaux/reseau_andre_picard_biologie_du_developpement.html)