A UK Science Requirements Framework for Future Marine Research Infrastructure

Summary Report

Foreword

“The next 20 years will be critical for the future of our planet. As environmental pressures intensify - from climate change and biodiversity loss to the degradation of ocean systems - the need for ambitious, high-impact marine science has never been greater.

A UK Science Requirements Framework for Future Marine Research Infrastructure sets out a vision for the science we will need to meet these challenges head-on. It identifies the capabilities required to understand a rapidly changing ocean, support nature-based solutions, and guide evidence-based decision-making at all levels.

Building on NERC’s *Forward Look* vision for environmental science, this framework champions the science we need to shape the future: collaborative, inclusive, innovative, and deeply connected to societal need. It calls on us to lead a new era of marine research that not only continues to deepen our understanding of the ocean, but drives action for the thriving, sustainable future we urgently need.”

Professor Alex David Rogers, Lead Author

Deputy Director of Strategic Science Programmes and Partnerships

National Oceanography Centre

FMRI FUTURE MARINE RESEARCH INFRASTRUCTURE

UKRI Natural Environment Research Council

Introduction

The Future Marine Research Infrastructure (FMRI) programme, led by the Natural Environment Research Council (NERC), aims to secure a more resilient, future-ready research infrastructure to support UK marine scientists tackling urgent environmental challenges. Working in collaboration with the research community, FMRI aims to meet the marine research infrastructure demands of tomorrow, while aligning with UK Research and Innovation (UKRI) priorities for financial and environmental sustainability, and innovation. FMRI will underpin the UK's continuing global leadership in ocean science by enabling high-impact research to inform policy and benefit society. The Science Requirements Framework (SRF) provides a vital contribution to the FMRI Business Case for a strategic investment in future marine research infrastructure.

Enabling innovation and resilience through ocean science

The UK is a leader in both marine and wider Earth system science. Sustaining this position requires ongoing investment in marine observing infrastructure and the rapid adoption of digital technologies. These capabilities deliver the timely, accessible data, information and understanding which in turn underpins effective decision-making, a sustainable blue economy, better weather forecasting, coastal protection, hazard assessment and mitigation, climate action and conservation of marine biodiversity. This enables the UK to exert international influence on the governance of the global ocean.

About the Science Requirements Framework (SRF)

The SRF is designed to outline the UK's key marine science needs, from supporting a sustainable blue economy and addressing environmental risks, to fulfilling international commitments. By focusing on five Marine Science Grand Challenges, it identifies critical knowledge gaps that must be addressed to understand how ocean systems interact with the broader Earth system and responds to both natural and anthropogenic change. It also highlights the capabilities needed to meet future demands, and the importance of partnerships to maximise impact.

Built by the community and designed to evolve

To ensure the SRF reflects the needs of the UK's diverse marine science community, the five Grand Challenge chapters were developed by subject matter experts across career stages, disciplines, and organisations. Broader input was gathered through workshops, consultations, and external review by national and international science leaders. As a living document, the SRF will inform decisions about where to invest throughout the FMRI programme.

Marine Science Grand Challenges

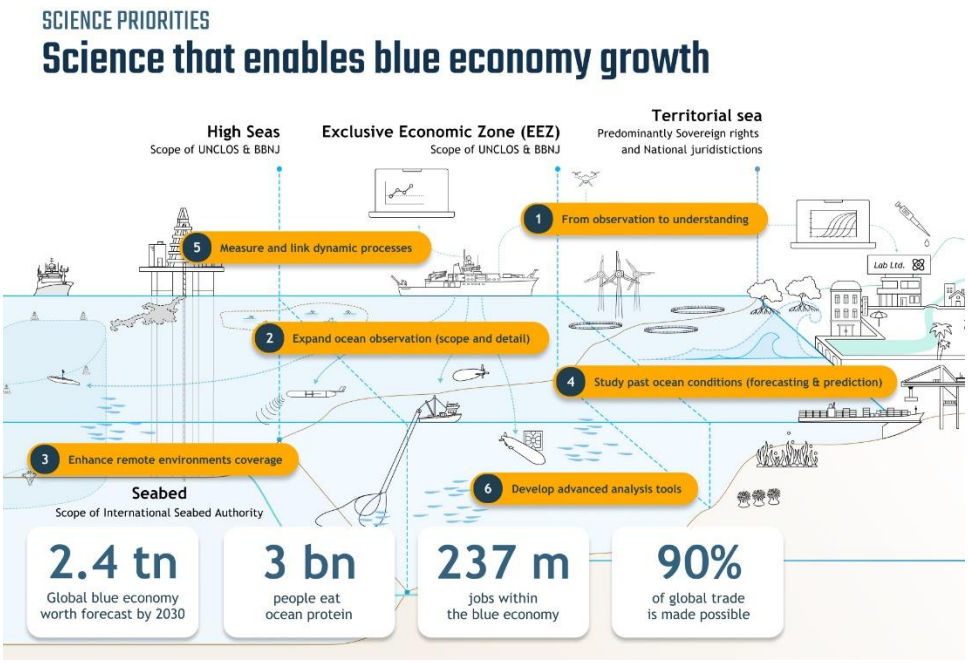
1. **The Role of the Ocean in a Changing Climate**
2. **Protecting Biodiversity and Ocean Health**
3. **Pollution: Its Sources, Distributions and Solutions**
4. **Strengthening Resilience to Natural Hazards and Extreme Events**
5. **Sustainable Blue Economy and Ecosystem Services**

These chapters and the subsequent synthesis chapters outline how the UK can build the infrastructure and research capability needed to advance marine science to support green growth, environmental security, and responsible innovation.

Recommendations and Priorities from the SRF

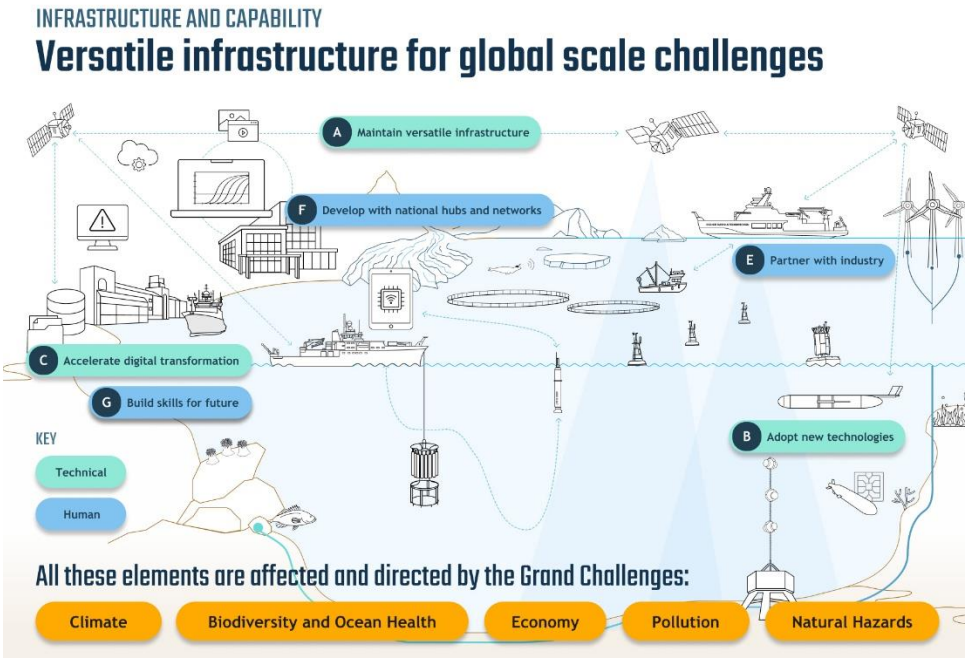
Science Priorities

- **Shift from observation to understanding**: A focus on understanding underlying physical, biogeochemical, biological and geological processes behind environmental changes will be essential for improving predictions and responses.
- **Expand ocean observations across spatial and temporal scales**: Increase the scope and detail of ocean observing across all scales, including biological, physical, biogeochemical, geological, and human activity data.
- **Enhance coverage of remote environments**: Ocean observing must cover hard-to-reach areas like polar regions, the open ocean-shelf-coastal interface, under ice, the deep sea and the subseafloor to better understand climate change impacts and carbon cycling.
- **Study past ocean conditions to understand the present and future**: Use sediment cores, marine fossils, and evolution of the seafloor to understand historical ocean changes and inform future predictions, including the nature of tipping points and the risks of exceeding their thresholds.
- **Measure and link dynamic processes**: Track how materials and energy move through ocean systems through fluxes and rates of key elements, including the effects of human impacts (like pollution and habitat change) and natural hazards on ecosystem structure and function.
- **Develop advanced analysis tools**: Invest in technologies including Artificial Intelligence (AI), models and Digital Twins to enhance and upscale data acquisition, processing and accessibility, enabling a step change in automated data collection, quality control, analysis, interpretation and use.



Infrastructure and Capability

- **Maintain versatile infrastructure**: Future systems must be flexible and capable of supporting a wide range of science needs across different scales and disciplines. A combination of ship-based and autonomous platforms are expected to continue to play an important role in such an integrated, versatile capability.
- **Adopt new technologies**: Accelerate the use of innovative tools like satellite and remote sensing, molecular techniques, computer vision and cable networks. New robust, low-cost, and long-term modular sensors will allow for broader and more precise data collection and should be deployed on existing and new autonomous platforms.
- **Accelerate digital transformation**: Improve how data is collected, stored, and shared, with near-real-time and real-time access and standardised formats for broader use by national and international stakeholders, making science more inclusive and engaging for a wider community (scientists, industry and the public).
- **Use digital tools for planning**: AI and digital tools can help optimise marine science operations and reduce their environmental impact.
- **Partner with industry**: Collaborating with businesses can improve data access, promote sustainable practices, and support technology development.
- **Develop national hubs and networks**: Create centres of expertise – physical and virtual – to support standardisation of training, collaboration, storage (samples and data) and open data sharing and use across the marine science community and beyond.
- **Build skills for the future**: Train new and existing scientists, engineers and support staff in digital transformation tools and multidisciplinary approaches to meet evolving marine science challenges. Such upskilling will further promote science-industry collaboration as workforce skillsets are matched. Utilise remote participation to foster inclusivity.



Conclusion

The SRF recognises the unique opportunity that FMRI presents to take a holistic and forward-looking approach to guiding the UK's future investment in its national capability for marine research, maximising societal and economic impact by combining emerging technologies and digital tools in new and innovative ways.

Building an integrated infrastructure for the future

The future of marine science depends on maintaining a versatile and integrated infrastructure that can support a broad spectrum of research needs. This includes leveraging both ship-based and autonomous platforms to enhance observational capabilities across scales and disciplines. Embracing innovative technologies will further enable cost-effective, long-term, and precise data collection and use. These advancements must be supported by a digital transformation that ensures data is collected, stored, and shared in standardised formats, with real-time accessibility and enhanced use capabilities to benefit scientists, industry, and the public alike. AI and other digital planning tools will play a critical role in optimising operations and reducing environmental impacts.

Collaboration and skills development

To fully realise this vision, strong collaboration between the broad research community, industry, and government is essential. Developing national hubs and networks will foster standardisation, shared expertise, and open data practices, while also supporting training and collaboration. Investing in skill development for both current and future marine professionals is equally vital, with a focus on digital competencies, multi-/interdisciplinary approaches, and inclusive access through remote participation. Together, these efforts will create a more agile, inclusive, and future-ready marine science ecosystem.

“On behalf of NERC and the FMRI programme, I’d like to thank everyone who contributed their time, expertise, and insight to this report. It was a genuinely collaborative effort – one that relied on shared thinking and collective commitment to succeed.

“This comprehensive review makes it clear that the UK’s future marine science research infrastructure must deliver an interoperable set of capabilities that support the entire marine science community.

“What’s particularly exciting is how the community continues to embrace innovation – adopting emerging technologies and forging new partnerships across disciplines to deepen our understanding of the most complex ecosystem on the planet. As we move into the next phase of the FMRI programme and continue developing the case for investment, we enter a pivotal stage and the SRF is a key step in building the case for strategic investment to maintain UK leadership in global scientific endeavour. Through continued collaboration, innovation, and investment, we can ensure the UK is equipped with world-class national capability marine research infrastructure, ready to meet the challenges of the future and deliver science that matters.”

Leigh Storey

FMRI Senior Responsible Owner

National Environment Research Council

The full report is available to download here.

Connect with the Future Marine Research Infrastructure (FMRI) programme

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