# Ocean Knowledge 2030

Ireland's Strategy for Marine Research, Innovation and Knowledge, 2025-2030

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**DRAFT FOR PUBLIC CONSULTATION**

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## Glossary of Acronyms

**BIM:** Bord Iascaigh Mhara

**CSO:** Central Statistics Office

**DAFM:** Department of Agriculture, Food and the Marine

**DECC:** Department of Environment, Climate and Communications

**DETE:** Department of Enterprise, Trade and Employment

**DFA:** Department of Foreign Affairs

**DHLGH:** Department of Housing, Local Government and Heritage

**DoT:** Department of Transport

**EI:** Enterprise Ireland

**EPA:** Environmental Protection Agency

**FI:** Fáilte Ireland

**GSI:** Geological Survey Ireland

**IL:** Irish Lights

**IMDO:** Irish Maritime Development Office

**INS:** Irish Naval Service

**LGMA**: Local Government Management Agency

**MARA:** Maritime Area Regulatory Authority

**MÉ:** Met Éireann

**MI:** Marine Institute

**MRFF:** Marine Research Funders' Forum

**MSO:** Marine Survey Office

**OECD:** Organisation for Economic Co-operation and Development

**SEAI:** Sustainable Energy Authority of Ireland

**UG:** University of Galway

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# 1.Introduction

The United Nations has designated the period from 2021 to 2030 as the Decade of Ocean Science for Sustainable Development. This reflects a global acceptance that a healthy and productive ocean is critical for planetary health and human health and well-being. Moreover, the Decade recognizes the important role of science and knowledge in helping us to achieve "the Ocean we need for the future we want".

This decade is also a critical time for Ireland as an ocean state with a large maritime area. We are on a pathway towards the largest transformation in how we use our ocean space in the history of the State. Ambitious national climate and energy targets require a major transition to renewable sources of energy. A national target of 5GW of installed offshore wind energy by 2030 requires the substantial accommodation of wind farm developments within our maritime area. This will impact on the environment and ecosystems in the vicinity of these developments but also on other established maritime sectors such as seafood production (fisheries and aquaculture), port activities and shipping.

Recent and forthcoming national and EU legislation in respect of marine spatial planning, marine protected areas, biodiversity protection and nature restoration will also have major implications for the use and protection of marine space and ecosystems. At the same time climate change and the effects of greenhouse gas emissions are resulting in warming seas, rising sea-levels, altered ocean chemistry, increasingly frequent extreme weather events and changing biodiversity and ecosystems.

Robust data, knowledge and expertise are essential to navigate these environmental, sectoral, policy and legislative pressures and their societal and economic impacts, and to deliver effective policy and management decisions.

The COVID-19 pandemic demonstrated the critical importance of having the necessary national capacity and knowledge base to address a generational societal challenge. While COVID represented an acute situation and required a rapid mobilization, it was the establishment of expertise and a robust research base over many preceding years that enabled government policy decisions and actions to be informed by the best available scientific knowledge and advice.

The same principle applies to the management of our vast ocean territory and resources. The National Marine Research and Innovation Strategy 2017-2021 provided a framework to guide policy-oriented marine and maritime research to optimize the beneficial impact of finite research and knowledge investments nationally. The building of national capacity across fifteen thematic areas was the central goal of the strategy, which used a 'Research Capability Maturity Model' to define and measure national capability by theme in relation to human capacity, infrastructures and networks.

There has been significant investment in Ireland's marine research and innovation sector over the past three decades. This has not only built considerable capacity and expertise in a wide range of marine and ocean topics, but it has also delivered national infrastructure such

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as laboratories, research vessels and the world leading, open-access marine maps and databases delivered and maintained by the Marine Institute and Geological Survey Ireland.

# 2. About this Document

Ocean Knowledge 2030 is Ireland's marine research, knowledge and innovation strategy for the period 2025-2030. The strategy has been developed under the coordination of the Marine Institute, in line with its mandate '*to co-ordinate, to promote and to assist in marine research and development*[1]'. As a national strategy, it has been created in partnership with - and is collectively owned by - the multiple government departments, state agencies and other stakeholder bodies that set, inform or implement marine policy and associated policy domains (e.g. environment, economic development, energy, food, etc.) and/or fund, coordinate and manage marine-related research and innovation.

The strategy identifies some of the most critical marine scientific and societal challenges that Ireland is facing and also the enormous opportunities presented by our extensive maritime domain and its rich resources. It also documents the existing, recent or forthcoming legislation and policy developments, whether at national or EU level, that will require a knowledge-based response and the associated questions that should be the focus of our research programming and investments over the coming five years.

Ocean Knowledge 2030 is a sectoral implementation mechanism that aligns directly with the national research and Innovation strategy, Impact 2030. It will help to coordinate the actions and investments needed to realise the Impact 2030 action to '*make Ireland an international leader in marine science and technology across the full R&I value chain'*. It also aligns and integrates with a broader suite of sectoral and Research and Innovation strategies and policies at both national and EU level. It presents a set of targeted actions with associated implementing actors to be advanced over the first two years of the strategy cycle (2025-2026). It is intended that a periodic review in late 2026 will inform an updated set of actions for the next phase of implementation from 2027.

A key implementing mechanism for the Strategy is the Marine Research Funders' Forum, a forum of departments, agencies, funders and stakeholders that was established in 2018 under the previous strategy, the National Marine Research & Innovation Strategy (2017-2021). A review on the effectiveness and impact of that strategy[2] was a key starting point to guide the development of Ocean Knowledge 2030. The Marine Research Funders' Forum has played a key role in steering the new strategy and will be an important structure to guide and mobilise action on its implementation.

A national database of marine research investments established in 2017 with data provided routinely by the MRFF partners, is also a key tool to inform research and innovation programming, coordination and investment across the research system. One of the first

[1] Marine Institute Act, 1991

[2] Interim Review of the National Marine Research & Innovation Strategy 2017-2021, Indecon Economic Consultants, 2021.

actions of Ocean Knowledge 2030 will be to establish an implementation and impact framework (Chapter 6), to ensure that the Forum members can monitor and measure progress on its implementation.

Ocean Knowledge 2030 is structured to address firstly the research and knowledge needed to better understand the natural coastal, marine and oceanic environment that surrounds Ireland and impacts on our daily lives. It reflects the increasing need to understand how this important environment is being impacted by climate change and human activities and how we can inform and evolve our response to these changes. (Chapter 3 – Living with a Changing Ocean). Chapter 4 focuses on Ireland's Ocean economy and identifies the research and knowledge needs to support economic development and sustainability across five key ocean economy sectoral areas. Chapter 5 looks at the elements of the research, knowledge and innovation system that are key 'enablers' to ensure we can progress all aspects of the strategy, addressing systemic aspects such as human capacities, research infrastructures, data, partnerships, and funding.

Throughout the strategy the term 'research, knowledge and innovation' is used to encompass the breath of scope of many of the identified gaps, challenges and proposed actions. 'Research' focuses on the generation of new knowledge through the scientific process or empirical methodology, while 'innovation' refers to the application of such knowledge to deliver new solutions, products, or services to real-life challenges, whether in a commercial setting or supporting outcomes in the public interest. 'Knowledge' was included to take account of the enormous bank of existing knowledge that already exists within the system, whether in research or technical publications and reports, or in the expertise of researchers in our academic institutions and public research bodies. As the title suggests, Ocean Knowledge 2030, is about applying knowledge, whether new or existing, to advance Ireland's ambitions in developing a productive and sustainable ocean economy, and in safeguarding and managing our extensive maritime area and marine resources.

The Vision and High-Level Objectives of Ocean Knowledge 2030 are set our below.

## 2030 Vision

Marine research, knowledge and innovation play a pivotal role in accelerating the transition to a sustainable and climate-neutral blue economy, maintaining a healthy marine environment, and fostering a society that coexists with the ocean

## High-level Objectives

1. Guide, align and coordinate research & innovation investments in line with national, EU and international strategic priorities.
2. Ensure marine and maritime research, innovation and knowledge deliver maximum impact and value to users and stakeholders.
3. Help realise the Impact 2030 goal to 'make Ireland an international leader in marine science and technology across the full R&I value chain.'

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# 3. Living with a Changing Ocean

## 3.1 The Ocean-Climate Nexus: Ocean physics and chemistry

The seas and oceans that surround Ireland are part of a global ocean that covers 71% of the earth's surface and is changing on human timescales. Ocean processes, ecosystems and biodiversity are being impacted by human activities and human-induced climate change, most notably the continuing emissions of greenhouse gases (GHG) into the atmosphere. By absorbing more than a quarter of human-generated Carbon Dioxide ($CO_2$) and about 90% of the heat generated by the effect of greenhouse gases, the ocean has limited the warming of the planet and provided a buffer against the impacts of climate change. But this has come with consequences.

Since 1993 the rate of ocean warming has more than doubled while marine heatwaves have doubled in frequency since the early 1980s and are increasing in intensity. Global sea level has risen by 0.2m since 1900 and the rate of global sea-level rise is accelerating[3]. The ocean has undergone increased acidification while ocean deoxygenation is becoming more widespread.

Several studies have suggested that the Atlantic Meridional Overturning Circulation (AMOC), a system of ocean currents, including the Gulf Stream, that transports warm, shallow water northwards, and returns cold deep water to the south, has weakened in recent decades. However, this is not yet confirmed as a trend, nor has a similar weakening been observed in the Gulf Stream. Neither is it yet clear how to distinguish any trends from underlying inter-annual to decadal variability. Nevertheless, a weakening of around 20% in the AMOC is expected by the end of this century and collapse remains a possibility in the longer term beyond 2100[4], with profound implications for Europe's climate.

The changes in the seas around Ireland in many cases reflect those at regional (NE Atlantic) and global scale and are comprehensively synthesized in Irish Ocean Climate and Ecosystem Status Report 2023[5]. The detailed overview of the current status of climate and climate science in this report, and the EPA's Ireland's Climate Change Assessment Synthesis Report[6], are of the highest societal and policy relevance.

However, global mean figures can also mask local and regional trends in key climate and ocean variables. Sea-level around Ireland has risen by 2-3mm per year since the early 1990s. Sea surface temperatures off Ireland's North Coast (Malin Head) were 0.47°C higher over the

[3] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, et al (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–35. https://doi.org/10.1017/9781009157964.001.

[4] A sea of change: Europe's future in the Atlantic realm (2021). Report of the European Academies Science Advisory Council (EASAC).

[5] Nolan, G., Cusack, C., Fitzhenry, D. (Eds.) (2023). Irish Ocean Climate and Ecosystem Status Report. Marine Institute, Galway, Ireland, pp 192.

[6] Thorne, P. et al, 2023, Ireland's Climate Change Assessment: Synthesis Report. Environmental Protection Agency, Ireland, 36 pp

last 10 years compared to the period 1981-2010, while Irish surface coastal waters have become more acidic since the early 1990s rate that is higher than the global average[3,4].

In response to these observed ocean and climate changes, substantial progress has been made nationally to advance legislation and to promote actions for climate mitigation and adaptation. The Climate Action and Low Carbon Development Act of 2015 (the Climate Act) subsequently amended in 2021, is the legislative basis for multiple climate plans, policies and new implementation structures, including the annually updated Climate Action Plan (CAP), the National Adaptation Framework, the Climate Change Advisory Council, the National Framework for Climate Services (coordinated by Met Éireann) and the establishment of four Climate Action Regional Offices (CAROs).

The successful implementation of the growing suite of national climate plans, policies and actions depends on robust scientific research, data and evidence. It is critically important for coastal States like Ireland to support ocean and coastal observing and research programmes and to monitor and understand changes that are taking place at an appropriate scale. Tracking a range of 'Essential Ocean Variables' (EOVs) and monitoring our changing coastline is essential to provide the data and evidence needed to inform policy and planning and to enable society and impacted economic sectors to adapt, mitigate and manage climate related impacts.

With the ambitious climate targets, policies and plans that are now in place, it is important that future research and technological innovations are targeted at the most critical knowledge gaps and at building national capacity for the long-term sustainable monitoring of essential ocean (including coastal) and climate variables and policy- and solutions-focused research. The Framework to Guide Climate and Climate-Related Strategic Research and Innovation, established under the Climate Action Plan 2024, is a key mechanism to achieve this imperative. There is also a need to coordinate the increasingly complex research system that supports ocean, coastal and climate research across multiple programmes and investments. This will also ensure that Irish-based researchers can compete effectively for international research funding, and foster a robust pipeline of research talent and expertise in collaboration with international partners.

**Key Actions 2025-2026**

| Action | Implementation |
|---|---|
| 1. Ensure ocean and climate research challenges, including those identified in the Irish Ocean Climate and Ecosystems Report 2023, are reflected in the annual Climate Action Plans and the outputs of the forthcoming Framework to Guide Climate and Climate-Related Strategic Research and Innovation. | DECC, MI, MÉ, GSI |
| 2. Increase investment and national capacity in ocean, seabed and coastal modelling, the development of sector-specific digital twins, and the advancement of digital products and | MI, MÉ, DECC, DAFM, DHLGH |

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| Action | Implementation |
|---|---|
| innovation to underpin national climate and planning policy and the provision of climate services. | |
| 3. Establish an implementation and monitoring framework for the multiple research recommendations made in the Irish Ocean Climate and Ecosystem Status Report 2023 and a mechanism and resourcing to secure future updates of this national assessment at appropriate intervals. | MI, ME, DECC, DAFM, DHLGH |
| 4. Advance Ireland's leadership role in international climate-related ocean and coastal research initiatives, including the Horizon Europe Missions, JPI Climate and JPI Oceans, World Meteorological Organisation marine and coastal programmes, and the contribution of Irish experts to the IPCC assessment process. | MI, EPA, ME |

## 3.2 Marine geology, seafloor and coastal change

Ireland has a coastline more than 7,500 Km in length and a maritime territory (Exclusive Economic Zone and extended continental shelf) of 488,762 $Km^2$, seven times its landmass. Since 1999 seafloor morphology and shallow geology has been systematically mapped through INSS and INFOMAR programs. This a highly valuable state asset that directly addresses many research and innovation challenges, as laid out in Ireland's National Development Plan 2021-2030. Although initial mapping is scheduled for completion in 2026, there is still a need to enhance this data resource and maintain & grow expertise – in order to build on the requirements of Action MA/24/3 of the government's Climate Action Plan 2024 & meet Ireland's obligations under SOLAS - International Convention for the Safety of Life at Sea.

Seafloor conditions provide an underlying baseline for chemical, biological and human activity in the ocean. Seafloor composition and sub-seafloor information reflect the changes in climate and oceanographic conditions experienced by Ireland. Further data collection and research is needed to improve understanding of sediment dynamics and transport systems both at open seas and coastal areas.

Rising sea levels and more frequent extreme sea level events (ESLs), combined with coastal erosion, are projected to have profound impacts on communities and infrastructure. It is also projected that much of this impact is expected to occur over the next decades and could potentially affect up to 2 million people, all the major cities, and much of the country's industry and infrastructure and utilities. Department of Housing, Local Government and Heritage established the National Coastal Change Management Strategy with a view to an integrated, whole of Government strategy.

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**Key Actions 2025-2026**

| Action | Implementation |
|---|---|
| 5. Support capacity-building measures to enhance the future pipeline of talent and expertise in the areas of marine geology, geophysics, hydrography and coastal change. | GSI, MI |
| 6. Increase investment and national capacity in ocean mapping, geological and paleoclimate research, and coastal behaviour; and the advancement of digital products and innovation to underpin national policies. | GSI, MI, DECC |
| 7. Advance Ireland's leadership role in international ocean mapping and coastal initiatives, including the Horizon Europe, EMODnet and International Ocean Discovery Programme (IODP). | MI, GSI |
| 8. Advance national coordination and data life cycle management in ocean mapping and coastal change. | GSI, MI, |

## 3.3 Marine biodiversity and ecosystem functioning

Ireland's marine habitats include deep offshore continental shelves and canyons, and a range of inshore coastal habitats from steep cliff faces to sandy and rocky sea shores, kelp forests, estuaries and salt-marshes. Ireland's marine ecosystems are home to a rich and diverse range of marine mega- and macro-fauna, including 24 species of cetaceans (whales, dolphins and porpoises), two seal species (the Common Seal and the Grey Seal), 24 resident sea-birds, 35 species of shark and more than 150 species of marine fish. In addition, our waters and seafloor sediments have abundant smaller invertebrates, algae, plants and micro-organisms which comprise an enormous diversity and biomass and are essential components in marine food webs and ecosystems.

However, the impacts of climate change and human activities pose substantial threats to marine biodiversity and the health and functioning of marine ecosystems. In recent decades, scientists have observed and documented changes in the geographical range and seasonal activities for many marine species resulting in altered species composition and abundance, and biomass production of ecosystems, from the equator to the poles. Extinction threatens at least 48 species living in the Irish marine environment, including fish, crustaceans, shellfish and invertebrates[7].

In 2020, Ireland published its updated assessment to the EU's Marine Strategy Framework Directive (MSFD) which aims to protect and conserve the health of the EU's coasts, seas and ocean. It showed that five out of eleven descriptors had achieved Good Environmental status (GES) with three descriptors partially achieving GES (an updated assessment is due in 2024). Knowledge gaps and challenges remain, however, for the full and effective implementation

[7] Ireland's 4th National Biodiversity Action Plan 2024

of the MSFD including, for example, establishing appropriate monitoring methodologies for marine micro-litter.

The European Union's 2030 Biodiversity Strategy sets ambitious targets and commitments for 2030 to designate 30% of our maritime territory as Marine Protected Areas (MPAs), in line with equivalent commitments under the UN Convention on Biological Diversity (Kunming Montreal targets, 2021) and currently being transposed into national legislation via the forthcoming MPA bill.

Currently, Ireland has designated just under 10% of its maritime area as protected in the form of Special Protected Areas (SPA) and Special Area of Conservation (SAC). Notably, Ireland's first marine park was established in 2024, centred around Corca Dhuibhne in Co. Kerry and covering an area of 70,000 acres of land and sea. The MPA bill will set out provisions regarding roles and responsibilities for the identification, designation and management of further MPA sites.

The recently agreed EU Nature Restoration Law will add another layer of legislation, aiming to strengthen progress in halting biodiversity loss and in restoring degraded ecosystems. The Horizon Europe Mission, Restore Our Oceans and Waters by 2030, is also an important framework for EU Research & Innovation to progress science-based measures to protect and restore ecosystems, with measurable targets.

Protecting and conserving our marine biodiversity relies on essential research, data and evidence to understand both baseline conditions and patterns of change linked to climate change and the direct impacts of human activities. Ireland has a well-coordinated research community that is active in national and international research projects and programmes in the area of marine biodiversity and ecosystems research. The substantial research effort across the Higher Education Institutes is underpinned and augmented by statutory and science-driven marine monitoring programmes carried out by government bodies linked to EU Directives and other international commitments.

These programmes are crucial parts of the evidence base. However, there is potentially a deficit in the pipeline of talent and expertise in the area of marine biodiversity, taxonomy and ecosystems that will be needed to support the step-change in the requirements for scientific advice linked to the development of ORE, the establishment of a substantially larger network of MPAs, and other nature restoration efforts.

**Key Actions 2025-2026**

| **Action** | **Implementation** |
|---|---|
| 9. Support capacity-building measures to enhance the future pipeline of talent and expertise in the areas of marine biodiversity, taxonomy, ecology and ecosystems research. | Research Ireland, MI |
| 10. Enhance Ireland's leadership and participation in the second phase of the Horizon Europe Mission, Restore our Ocean and Waters by 2030 | MRFF, MI |

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## 3.4 Ocean governance and law

Ocean governance addresses the legal, planning and policy frameworks that seek to manage and regulate multi-dimensional and interconnected human activities in the ocean space. Ocean governance is applied at multiple geo-political and temporal scales; there is no single policy, institution or actor that has exclusive authority in this realm. There are routine challenges faced by policy-makers in Ireland to integrate EU and international commitments into national policy and management frameworks. However, the last five years have seen substantial changes in national policy, planning and legislation pertaining to the usage of maritime space and commercial activities at sea which also have implications for the conduct of marine scientific research and data collection.

The Marine Area Planning Act 2021 represents the biggest reform of marine governance since the foundation of the State. This critical piece of legislation brings marine planning and consenting up to date and, in particular, enables the state-led planned expansion of Offshore Renewable Energy (ORE), all managed within the National Marine Planning Framework (Ireland's Marine Spatial Plan) and operationalised through the establishment of a new authority, the Maritime Area Regulatory Authority (MARA).

Forthcoming legislation on Marine Protected Areas will provide the legal basis for Ireland to meet its EU and international commitments to designate 30% of its maritime area as MPA by 2030. Given the scale of legislative reform, challenges are expected in relation to cross-compliance and conflicts may arise from complex interactions between legal and policy instruments. In this context, there is a greater need to ensure that Ireland retains and builds its national capacity and expertise in maritime law, ocean governance and integrated marine policy and planning. At the same time, Ireland has responsibilities to contribute to international ocean governance through participation in multiple EU and UN assessments, working and advisory bodies, including initiatives under the United Nations Convention on the Law of the Sea, UN Safety of Lives at Sea, the International Maritime Organisation, the International Seabed Authority and the International Oceanographic Commission of UNESCO.

The 2023 UN Agreement on Marine Biodiversity Beyond National Jurisdiction (BBNJ) is expected to enter into force in the coming years. The BBNJ Agreement, in broad terms, aims to close significant gaps in global ocean governance by providing a framework to enhance protection of the marine environment. A crucial feature of the Agreement is a global mechanism for establishing marine protected areas (MPAs) in areas beyond national jurisdiction, namely the high seas and international seabed. These areas comprise two thirds of global ocean space but only 1% is presently protected by MPAs, far short of what is envisaged by the "30 by 30" target of the Kunming-Montreal Global Biodiversity Framework agreed at the Convention on Biodiversity COP15 in December 2022. In addition to its provisions on MPAs, the Agreement will strengthen the global regime for the conduct of environmental impact assessments (EIAs) for activities that may have an impact on the marine environment in areas beyond national jurisdiction. Furthermore, the Agreement makes provision for a benefit sharing mechanism in respect of marine genetic resources

(MGRs) and contains provisions on capacity building and technology transfer to support developing countries.

In 2023, the Government announced its support for a precautionary pause of deep-sea mining on the international seabed, which is regulated by the International Seabed Authority, of which Ireland is a member. Ireland's position is that no deep-sea mining should take place until such time as a robust regulatory framework is in place to protect the marine environment and the scientific knowledge base is sufficient to allow for informed decision-making. Similarly, the government's Policy Statement on Mineral Exploration and Mining (December 2022) provided that mining activity should not take place on the Irish seabed until such time as sufficient data is available to adequately assess the potential impacts.

**Key Actions 2025-2026**

| Action | Implementation (tbc) |
|---|---|
| 11. Coordinate the necessary research, skills and capacity assessments required to inform the ongoing development of the State's new planning, consenting and regulatory functions and the associated mechanism to ensure provision of relevant data and evidence to inform their activities. | DECC, MARA, MI |
| 12. Commission a desk-based study to ascertain the national impacts and implications of the BBNJ Agreement, and to examine how Ireland can best contribute to achieving the objectives of the Agreement through marine research, and through related capacity building and transfer of marine technology activities to assist developing countries. | DHLGH, DFA, MI |
| 13. Contribute to BBNJ-related capacity building and transfer of marine technology activities to assist developing countries, including through the provision of training/placement opportunities to scientists from developing countries. | DHLGH, DFA, MI |
| 14. Support and contribute to marine research relating to deep-sea ecosystems and related matters to help to inform the work of the International Seabed Authority, and support and contribute to relevant capacity building activities to assist developing countries. | DHLGH, DFA, MI |

## 3.5 The ocean's benefit and service to society

There are multiple ways that people benefit either directly or indirectly from the ocean. Marine ecosystem services are the services provided by the processes, functions and structure of the marine environment that directly or indirectly contribute to societal welfare, health and economic activities[8]. Ireland's marine resources provide a range of ecosystem services and benefits that contribute to societal welfare, health and economic activities. This

[8] Austen M.C., *et al* (2019) Valuing Marine Ecosystems - Taking into account the value of ecosystem benefits in the Blue Economy. Future Science Brief 5 of the European Marine Board, Ostend, Belgium. 32pp. ISBN: 9789492043696 ISSN: 4920-43696 DOI: 10.5281/zenodo.2602732

includes provisioning services, regulation and maintenance services, and cultural services that can have both market and non-market values.

Marine biodiversity, for example, plays an important role in providing ecosystem services such as fisheries, aquaculture, biotechnology and an arena for tourism and recreation. The many shipwrecks and submerged archaeological sites which have been mapped by the INFOMAR[9] programme in Ireland's territorial waters are an important part of our maritime cultural heritage and the object of archaeological study. Our marine environment also provides a number of regulating services such as carbon sequestration[10]. Ireland's stock of coastal, shallow water and tidally influenced blue carbon ecosystems such as seagrass beds and saltmarshes are estimated to store at least 9.2 Mt of carbon. The market values of these services can be quantified in monetary terms by the economic methodologies. Non–market values can also be quantified in monetary terms and research is underway to advance consistent approaches in quantifying these ecosystem service monetary values.

The relationships between people and the ocean has been the subject of the ocean literacy movement for more than a decade and national efforts are now coordinated under the Irish Ocean Literacy Network (IOLN). About 40% of the Irish population lives within 5km of the coast and coastal communities and businesses are intimately connected to their coastal and marine landscape and infrastructures but are also on the front line of climate change and extreme weather events. Understanding the attitudes and perceptions of citizens in relation to the role of the ocean in their lives and their own impacts on the ocean is an important field of social study in its own right. Building our national capacity in social and economic research linked to the oceans relationship with society will be important to enable some of the major developments that are planned over the next decades, including the installation of offshore renewable energy infrastructure.

In addition, citizen science is a research methodology which, if used correctly, offers huge potential to further scientific knowledge and to influence the environmental impacts of society through behavioural education. Marine citizen science also empowers citizens to engage constructively in the development and implementation of truly fit-for-purpose and evidence-based maritime policy[11].

**Key Actions 2025-2026**

| Action | Implementation (tbc) |
|---|---|
| 15. Advance national coordination and capacity in marine socio-economics and ocean economy measurement, including further progress towards an ocean economy satellite account for Ireland. | MI, UG, CSO, OECD |

[9] www.infomar.ie
[10] Cott, G. M., Beca-Carretero, P., and Stengel, D. B. (2021). Blue Carbon and Marine Carbon Sequestration in Irish Waters and Coastal Habitats. Marine Institute, Ireland.
[11] Garcia-Soto, C., et al. (2017) Advancing Citizen Science for Coastal and Ocean Research. Position Paper 23 of the European Marine Board (EMB), Ostend, Belgium. 112pp. ISBN: 978-94-92043-30-6

| Action | Implementation (tbc) |
|---|---|
| 16. Establish a biannual 'Ocean Barometer' survey on citizen attitudes and perceptions on ocean health, policies, issues and impacts. | MI, UG |

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# 4. Towards a sustainable ocean economy

The ocean economy is defined as any economic activity that directly or indirectly uses the sea as an input or produces an output for use in a sea-specific activity. It includes a range of established and emerging sectors that provide essential employment in coastal regions. Since 2016, the Marine Institute and the University of Galway have co-produced an annual report on Ireland's Ocean Economy which provides a periodic update and trends analysis on the ocean economy across three main economic indicators: turnover, gross value added (GVA) and employment (full-time equivalents or FTEs).

The 2023 report provides the most recent figures for the reporting year 2022. In terms of direct impact, the ocean economy generated €7.01 billion in turnover, a GVA of €2.85bn and supported 33,452 jobs (FTEs). This time-series data tells us that the ocean economy has approximately doubled in size across all three indicators in the fifteen-year period since 2007. While this is positive, there is potential for this steady state growth to be replaced by a much greater rate of growth in the next decade, driven largely but not exclusively by the expansion of offshore renewable energy (ORE) and associated value chain activity.

Across multiple sectors, from seafood production, to shipping and ports, or coastal and marine tourism, the future ocean economy will be data and knowledge-driven and employ advanced technology and engineering. This new ocean economy, as described by Spinrad (2016), 'puts science and predictive capabilities to work in a way that can fill critical, fast-rising needs across sectors. This economy is entrepreneurial and environmentally responsible, collaborative and competitive.' To enable this there are multiple research, knowledge and innovation (RKI) needs and opportunities, to address critical knowledge gaps, underpin technology development, address policy, planning and governance challenges and underpin innovation in the development of new products, processes and business models.

Here we identify the key research, knowledge and innovation (RKI) priorities that need to be addressed to underpin sectoral growth and development, along with key actions to facilitate progress, in five key sectors:

- Sustainable food from the ocean
- Energy from the ocean
- Greener and smarter ports and shipping
- Tourism in marine and coastal areas
- Safe and secure seas

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## 4.1 Sustainable food from the ocean

The rapid rise in global population and challenges associated with land-based food production mean that food from the ocean is becoming increasingly important for nutrition, livelihoods and global food security. Fisheries and aquaculture products are an important source of protein and can form a crucial component of a healthy diet. The world's consumption of fish or seafood has risen from a per capita average of 9 kg in the 1960s to 20.2 kg in 2022, with an EU average in 2019 of 25 kg per capita. In order to maintain this level of consumption in 2050, aquatic food production would need to grow by 22% globally (14% in Europe) (FAO, 2023)[12].

Recent reports indicate that the ocean could provide six times as much food as it does today, in particular through growth in low-impact, regenerative aquaculture[13]. Globally, therefore, a key challenge is to reconcile the required increase in production, with challenges such as declining fishery resources, inadequate governance frameworks, illegal unregulated and unreported (IUU) fishing, marine ecosystem degradation, competition for ocean space, and the impacts of climate change.

Achieving a sustainable supply of safe, secure and nutritious seafood requires a holistic food systems and circular bioeconomy approach, taking account of the full value chain from catch/production to consumption and management of waste streams. The pandemic, and increased geo-political tensions, have interfered with global supply chains and threatened food supply. The increasing attention within Europe on strategic autonomy also mitigates towards food sovereignty for EU Member States and increased importance on local production systems.

The seas around Ireland are among the most productive and biologically sensitive areas in EU waters. Fisheries, aquaculture and seafood processing are established sectors for Ireland's ocean economy, with a combined Gross Value Added (GVA) of €360m in 2022. In the same year, total production (fisheries and aquaculture) of marine fish and shellfish by volume amounted to 217,500 tonnes with a first sale value of €532m. The seafood sector employed approximately 8,218 FTEs with a further 7,155 jobs provided through downstream, value-chain enterprise[14], providing important employment opportunities in peripheral regions around the Irish coast.

Seafood forms part of the broader focus on Ireland's ambition to become a world leader in sustainable food systems, as outlined in Food Vision 2030[15]. Food security and nutrition are key components of Sustainable Food Systems, particularly the link between food and health. In line with national and EU[16] and international[17] policy objectives, Ireland's seafood sector needs to accelerate its development towards low impact, knowledge-driven, high-tech and

[12] FAO State of World Fisheries and Aquaculture 2022
[13] Costello, C., L. Cao, S. Gelcich et al. 2019. The Future of Food from the Sea. Washington, DC: World Resources Institute. Available online at www.oceanpanel.org/future-food-sea
[14] Source: BIM Business of Seafood 2022. Numbers do not include landings of non-Irish vessels in Irish ports
[15] Food Vision 2030 – A World Leader in Sustainable Food Systems
[16] EU Farm to Fork Strategy. https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
[17] FAO Blue Transformation Roadmap 2022-2030.

climate neutral production, optimising opportunities for equitable employment, innovation, food security, and sustainable economic growth in coastal areas.

A key challenge will be to continue to develop the seafood sector in the context of a rapidly changing use of marine space that will result from the planned expansion of Offshore Renewable Energy (ORE) and meeting EU and international commitments for conservation of marine ecosystems and biodiversity (including the designation of 30% of Ireland's maritime area as Marine Protected Area by 2030). Research, Development and Innovation (RDI) are central to addressing these complex challenges and to creating knowledge and opportunities for development of a sustainable and climate-neutral seafood sector. Research impact can be strengthened by embedding co-creation and co-implementation practices, involving industry, coastal communities and other stakeholders.

**Research, Knowledge and Innovation Priority Areas**

- Continued development and application of new tools and technologies (Aquatech and Biorefinery) in support of sustainable seafood production and processing, including land-based recirculating aquaculture systems (RAS), novel feed solutions, digital tools, Artificial Intelligence, marine engineering, fish health and genetics.
- Further development of low-impact, non-fed aquaculture, in particular seaweed and molluscs; integrated multi-trophic aquaculture; and opportunities for co-location of aquaculture with other developing offshore activities (e.g. offshore wind developments).
- Further development of frameworks for and application of Integrated Ecosystem Assessments in the context of ecosystem-based fisheries management, to inform policy and management decisions taking account of ecological, social and economic factors.
- Investigation and assessment of the potential for lower-trophic level, mesopelagic biomass as a target for fisheries, including understanding of the potential impacts on food chain dynamics, oceanic carbon-cycling and ecosystem functioning and the viability of associated seafood products for domestic and international markets.
- Adaptation of seafood production (capture fisheries and aquaculture) to the impacts of climate change including warming seas, sea-level rise, ocean acidification, extreme weather events and transitioning to a 'green' supply chain (fishing fleets, production, processing, transport, etc.) and circular blue bioeconomy[18].
- Increase research, knowledge and expertise on emissions and resource use by the seafood sector balanced against carbon sequestration and other ecosystem service provision by the sector and how this is regulated for optimum outcomes.

[18] Ireland's Bioeconomy Action Plan 2023-2025

- Advancing science-based measures to detect, monitor and address fish / shellfish disease and contamination, fish welfare, seafood safety and traceability in support of producers and consumers.
- Increased RDI capacity and activity on the role and importance of seafood in terms of nutrition, health, and well-being both nationally and globally, and the value consumers place on the sustainability of seafood products.
- Support for marine biotechnological research to support innovation in the development of high-value non-food products and services (e.g. marine proteins), promoting the use of side streams and other biomass and advancing circular bioeconomy principles.
- Developing and applying marine economics and socio-economics (including Natural Capital Accounting), social sciences and humanities applications for sustainable seafood sectoral development. (e.g. social licence, measurement of economic activity, links to ecosystem service provision).

**Key Actions 2025-2026**

| **Action** | **Lead (tbc)** |
|---|---|
| 17. Design and implement a dedicated RDI programme on 'Sustainable Food from the Ocean' with coordinated funding and multi-annual calls linked to the RDI priorities set out above. The programme should target tangible and measurable impacts in advancing all stages of the seafood value chain, taking account of barriers linked to markets and regulation to deliver a world-class seafood production that is sustainable, safe, secure and supporting innovation across the value chain. | MI, DAFM, BIM |
| 18. Align cross-programme opportunities to support research in the blue bioeconomy leveraging national funding mechanisms and EU programmes including the European Maritime Fisheries and Aquaculture Fund and the Sustainable Blue Economy Partnership (SBEP), promoting the transition to sustainable, low-carbon, low impact seafood production. | MI, BIM, Research Ireland, DAFM |

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## 4.2 Energy from the Ocean

The EU Green Deal sets Europe on course to be the first climate neutral bloc globally by 2050. This is matched with ambitious targets for climate action and decarbonisation of our energy systems. The move away from fossil fuels, initially driven by climate and sustainability factors, is now also an imperative for Europe's energy security in light of the Russian war in Ukraine and other global geo-political factors, influencing a move towards greater strategic autonomy for the continent.

In successive Climate Action Plans since 2021, Ireland has matched the ambition of the EU in setting a target to become a zero emissions economy by 2050, with a specific target to reduce GHG emissions to 51% of 1990 levels by 2030[19]. Our transition to renewable sources of energy will be a substantial component of the change needed to meet these climate targets. The largest and most important arena for building a renewable energy infrastructure is our 490,000 $km^2$ maritime area with wind and wave conditions that make it a significant potential resource for energy generation.

Ireland has set specific targets for offshore renewable energy (ORE) which has required a transformation of our regulatory and planning regime and modification of our governance and institutional arrangements. These targets require that we will achieve 5 GW of offshore wind energy production by 2030, rising to 20 GW in 2040 and 37 GW by 2050 through the construction of offshore wind developments off our eastern, southern and western coasts. Achieving our 2050 target could enable Ireland to become a net exporter of renewable electricity to our European neighbours.

Building a new offshore energy infrastructure at scale brings with it complex and interconnected technological, environmental and social challenges. The offshore energy transition will be State and plan-led and will require a substantial knowledge and evidence base to aid policy, planning and management. The development of ORE installations will also significantly impact existing maritime activities, including for example, fisheries, aquaculture and maritime transport. These sectors are vital for coastal economies, food security, and cultural heritage. Potential conflicts and synergies between ORE and these traditional marine industries need to be carefully studied and managed.

A major enabler for ORE development is the provision of data and digital products and services to establish baseline conditions, including for example the high-resolution INFOMAR marine maps provided by the Marine Institute and Geological Survey Ireland. These are critical to de-risk investments, to aid decisions on where to locate developments, and to avoid, mitigate and minimise impacts on the physical and biological components of the offshore ecosystem.

While technological advances continue to be made, wind energy generation has been at commercial deployment stage for two decades in Ireland. Nonetheless, there remain significant RDI challenges to reduce cost, optimize efficiency and lifecycle and to understand,

[19] https://www.gov.ie/en/publication/79659-climate-action-plan-2024/

manage and mitigate impacts on the environment and on other maritime sectors. Prototype technologies for wave and tidal energy have not progressed to commercialization at the rate that had been anticipated 20 years ago, and there remains a continued need to reinvigorate the advancement of these technologies as well as the potential for other ORE generators in the future.

The national capacity for ORE RDI was deemed to be at a mature level in the ex-post evaluation of the previous National Marine Research & Innovation Strategy, with a high level of expertise across the RDI ecosystem, support in place for MaREI as a Science Foundation Ireland Research Centre, and advanced research infrastructures and a RDI community that is well networked internationally[20]. Building upon this national capacity will be essential to support further RDI in the future.

**Research, Knowledge and Innovation Priority Areas**

There have been many assessments internationally of RDI needs in relation to ORE and wind energy in particular. The European Marine Board identified critical policy and research needs in its 2022 Future Science Brief, *European Offshore Renewable Energy: Towards a Sustainable Future*[21]. These needs are almost all relevant and applicable to the Irish context. Domestic economic opportunities which have been identified in the sector will be leveraged through strategic plans to promote technological innovation. There are 40 actions set out in *Powering Prosperity: Ireland's Offshore Wind Industrialisation Strategy*[22] and 29 actions set out in the *Future Framework for ORE Policy Statement*[23], which both include specific RDI-focused actions necessary to the effective delivery of our national targets.

Given the complexity of the challenge to establish an entirely new energy generation system in exposed offshore environments, the RDI needs are multi- and interdisciplinary and cross-sectoral. An aggregated set of RDI priorities is presented here under the four general categories of technological, environmental, governance and planning, and economic and social.

Technology and engineering for generation technologies, station keeping, turbine optimisation and grid integration.

- Offshore Wind: Continue support to further advance wind technologies, particularly for floating wind platforms, in relation to anchoring systems and foundation designs suitable for Ireland's challenging offshore environment. Design for optimised wind farm layouts, grid integration, and the impact of offshore wind on marine ecosystems. National supports should be targeted at advancing value chain products and services that offer opportunities for domestic companies to innovate and grow their businesses.

[20] Indecon International Economic Consultants, (2021). Interim Review of the National Marine Research & Innovation Strategy 2017-2021, Marine Institute, Ireland.
[21] Soukissian, T. *et al* (2023) European offshore renewable energy: Towards a sustainable future. Future Science Brief No. 9 of the European Marine Board, Ostend, Belgium. ISSN: 2593-5232. ISBN: 9789464206173. DOI: 10.5281/zenodo.7561906
[22] https://enterprise.gov.ie/en/publications/powering-prosperity.html
[23] https://www.gov.ie/en/publication/0566b-future-framework-for-offshore-renewable-energy/

- Wave Energy: Consider the support for developing efficient wave energy converters (WECs) that can withstand harsh marine conditions, improve power conversion efficiency, and reduce maintenance costs. Research can also explore the integration of wave energy converters into existing and future offshore infrastructure including wind farm arrays.
- Tidal Energy: Support further development of innovative tidal turbine technologies, optimised rotor designs, and advanced monitoring systems. Additionally, research can explore the environmental impact of tidal energy installations and potential strategies to mitigate any negative effects on the receiving environment.
- Energy Storage and Grid Integration: Support advanced energy storage systems, grid management solutions to address the connection of offshore renewables to the on-shore grid/network and demand-response mechanisms to address the capacity to manage intermittent generation sources with dispatchable types of energy generation to ensure a stable and reliable power supply.

<u>Understanding and managing environmental impacts</u>

- Support integrated research and monitoring studies to better understand the impacts (both negative and positive) of ORE installations and infrastructure development on marine biodiversity, ecosystems and habitats, including collision risk, underwater sound, electromagnetic fields, habitat impacts, marine refugia potential, and artificial reef effects and their expected future dynamics in the context of climate change.

<u>Knowledge for optimum governance, policy and planning</u>

- Investigate alignment and cross-compliance across diverse marine and coastal legislative and planning instruments to integrate ORE within a wider policy environment.
- Provide rapid response instruments to support specific knowledge needs for policy proposals being developed by competent government departments and the Offshore Wind Delivery Taskforce.
- Identify and address gaps in national datasets and regulatory processes to inform evidence-based policy and decision making for planning, consenting and environmental permitting to better enable project delivery, identify benefits and mitigate ecological and socioeconomic impacts of ORE.

<u>Economics, socio-economics, social and cultural</u>

- Social and behavioural research to support societal and local community understanding and the social license to operate for essential ORE projects.
- Research to track and predict impacts of ORE deployment on other maritime sectors (notably seafood and maritime transport) and users and optimising co-benefits and minimising potential for conflicts and optimising potential co-benefits.

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**Key Actions 2025-2026**

(Note: actions are aligned with RDI-related actions included in Powering Prosperity and the Future Framework for Offshore Renewable Energy, and the SEAI ORE Technology Roadmap.)

| Action | Implementation |
|---|---|
| 19. Increase and improve national coordination in providing targeted RDI supports to ORE value chain SMEs through existing and new programmes and calls. Maximise the value of research and innovation activities, where relevant, through business coaching, facilitating collaboration and wider enabling support. Ensure close coordination and alignment of different national RD&I programmes, and engagement with international, EU and European Space Agency programmes and coordination forums. | SEAI, EI, MI, Research Ireland, DETE, ME |
| 20. Accelerate progress on agreed actions under Powering Prosperity (Actions 26, 27, 28) and the Future Framework for ORE (Actions 3, 4) to plan, promote, support engagement with and use of existing marine test & demonstration facilities/sites and explore feasibility of additional marine test site (e.g. for Floating Wind). | SEAI, DETE, DECC, MI |
| 21. Develop a focused ORE Research & Innovation Strategy for Ireland with clear objectives, building on the ORE Technology Roadmap, and addressing gaps in support and monitoring ongoing technology developments and innovations24. | SEAI |

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[24] Action included in the SEAI ORE Technology Roadmap: https://www.seai.ie/technologies/ocean-energy//ocean-policy-and-funding/offshore-renewable-energy/Technology-Roadmap

## 4.3 Greener and Smarter Ports and Shipping

Maritime transport is responsible for moving 90% of Ireland's external trade. Virtually all sectors of the Irish economy rely on maritime transport within their supply chains. As a result, shipping routes between Ireland and our international markets are critical arteries for trade and Irish ports represent infrastructures of strategic national importance. Ireland's supply chains are also inextricably interconnected with the global supply chain system. The twin shocks of Brexit and COVID-19 resulted in renewed emphasis on improving Ireland's maritime connectivity to international markets, building additional resilience into our ports and shipping services and driving efficiency and competitiveness throughout the maritime industry.

Shipping is one of the least carbon-intensive ways to transport goods, generating 2.9 % of global anthropogenic $CO_2$ emissions in 2018. In the EU, ships generated 13.5 % of all greenhouse gas (GHG) emissions from transport in that year, substantially less than road transport (71 %) and aviation (14.4 %)[25]. As a heavy transport sector and one of the most internationalised of industries, sustainability and the need to deliver a better environmental performance is, nonetheless, a key driver of change in the maritime sector.

The 'Fit for 55' package, a set of legislative measures introduced in 2023 under the EU Green Deal, includes the FuelEU regulation, which seeks to transition the EU maritime sector towards carbon neutrality. This transition is already underway and will have significant implications for ship size and design; for ports and shoreside power infrastructure; and for skills and training of existing workers and new entrants to the sector. The inclusion of 2GW of Green Hydrogen in Ireland's climate targets and the potential for this to be exported in large volumes on vessels specifically constructed or adapted for that purpose, could also open a new opportunity for increased maritime transport business.

The need for the maritime transport sector to transition more broadly to a sustainable, resilient, efficient and digital future is reflected equally in the development needs for Ireland's ports. Ports play a crucial, yet often overlooked, role in facilitating economic growth and prosperity. As an island nation we depend on the quality and efficiency of our port services to a much greater degree than many of our trading partners[26]. There are particular opportunities linked to the development of smart ports, including introducing digital systems and processes for trade and shipping services that increase efficiency, while reducing costs and negative environmental impacts.

Ports, in particular regional ports, also provide substantial potential to diversify and to become clusters of blue economy business and activity, enhancing their traditional activities and attracting and hosting new business linked to evolving sectoral demands (e.g. ORE, aquaculture) and associated supply chains. Currently, there is insufficient consensus in the shipping industry in relation to fuels of the future to enable ports to invest in future infrastructure with confidence. Economic and social analysis will be key to inform policy and

[25] European Maritime Transport Environmental Report 2021. European Environment Agency (EEA)
[26] The National Ports Policy 2013

planning in relation to the growth in regional port capacity, port infrastructure development (e.g. for ORE, alternative fuels), the establishment of Green Shipping Corridors, and the development of ports as blue economy hubs.

The Irish Maritime Transport Economist[27] has tracked the development of the industry for more than 20 years and has established the correlation between the growth of the industry and that of the national economy. According to the Ireland's Ocean Economy Report, 2023, Shipping and Maritime Transport was the largest ocean economy sector in 2022 in terms of direct turnover, which amounted to €2.45bn in that year. The sector generated €664m in Gross Value Added and directly employed 4,728 FTEs. There are challenges and opportunities for the future development of this critical national sector that will require research, knowledge and expertise. These can be supported through coordinated capacity building measures within the Irish RDI system but also through integrating better and delivering greater impact through participation in EU and international programmes.

**Research, Knowledge and Innovation Priority Areas**

Research can improve Ireland's responses to complex questions in areas such as maritime economics, management of port infrastructure and investment, digital transformation, the achievement of climate neutrality, and cyber security. The importance of these questions calls for a co-ordinated research response that will ensure the Irish maritime industry remains fit for purpose and knowledge, data and evidence are employed to deliver a competitive advantage across all parts of the maritime transport sector.

Understanding indigenous and exogenous drivers and pressures affecting the sector

Economic, technical and policy analyses to define a baseline understanding of the current status and future development needs of Ireland's maritime transport ecosystem in an international context.

RDI to assess potential impacts and implications for maritime transport and port capacity of developments in other marine & maritime sectors, notably the impending rapid development and expansion of Offshore Renewable Energy (ORE).

Green and Smart shipping

Developing innovations in ship design, technology, operations and efficiencies to meet sustainability and climate change challenges through cleaner fuels and efficiency, noise and vibration impacts on the environment, pollution (including ballast water and alien species) and impacts of extreme weather conditions on sector operations.

There are questions to be answered in relation to the particular fuels and vessel types that will be used in the Irish shipping market. Research is needed to answer these questions and to inform port investments and policy decisions.

[27] Irish Maritime Transport Economist (Irish Maritime Development Office)

Consider expanded opportunities for vessel participation in marine environmental observing programmes such as Voluntary Observing Ship and Ship of Opportunity programmes.

Smart ports

RDI to inform policy and practice linked to the diversification of business activity for Irish ports and their potential to act as hubs for both primary and related services & activities such as logistics, distribution, training & education, marine technologies, coastal and marine environmental monitoring and coastal tourism.

RDI to inform the advancement of digitalisation across Ireland and Europe's ports and maritime transport system and develop a suite of port performance metrics, unique to the circumstances that prevail in each port. Such analyses will enable evaluation of how ports are delivering and when and if ports need to add capacity.

Economic and social analysis will be key to inform policy and planning in relation to the growth in regional port capacity, port infrastructure development (e.g. for ORE, alternative fuels), and the development of ports as blue economy hubs.

Fostering resiliency across all parts of the sector

Multi-disciplinary research to understand the threats and challenges to successful transition of the maritime transport sector (ports and shipping) and its workforce in the face of climate change and climate action impacts and the transition to a low-carbon, digital future to inform policy and practice, underpinning resilience across all aspects of the sector.

**Key Actions 2025-2026**

| Action | Implementation |
|---|---|
| 22. Engage with strategic partners in the UK and EU to identify opportunities for joint transnational investments and projects in greener and smarter ports and shipping, leveraging international funding streams. | MI, DoT |
| 23. Undertake a maritime RDI capacity assessment to determine capability within the system and critical gaps in knowledge and expertise that should be addressed through capacity building investments. | MI |

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## 4.4 Tourism in coastal and marine areas

Coastal and marine tourism constitutes approximately 50 percent of all global tourism, equal to US$4.6 trillion or 5.2 percent of global gross domestic product (GDP). It is a vital component of the economy of small islands and coastal communities[28]. In 2022 marine and coastal tourism in Ireland generated an estimated turnover of €1.3bn, a direct GVA of €535m and employed 18,325 FTEs[29]. It was the third largest marine and maritime sector in terms of turnover and GVA (after maritime transport and oil and gas exploration), but by a considerable margin the largest and most important sector in terms of the employment it provides. A sizeable fraction of these businesses and jobs are located in peripheral coastal regions where alternative employment options can be limited, adding to the sector's importance as a regional economic driver.

The establishment in 2013 of the Wild Atlantic Way has demonstrated the potential value of applying innovation in branding Ireland's tourism assets in a manner that has been transformational. Almost 2m more tourists visited the Wild Atlantic Way in 2023 compared with 10 years earlier, while tourism revenue on the route increased by 59% to €3bn and jobs by more than 40% in the same ten-year period.[30] Understanding the drivers of this success is key to ensuring continued innovation in the tourism sector.

Previous studies by the Socio-Economic Marine Research Unit (SEMRU) at the University of Galway not only provide an important understanding of the sector but also offer definitions that distinguish between coastal tourism, marine tourism and water-based activity tourism[31] [32] (in these reports international cruise tourism is considered a separate maritime sector). This categorisation is important as it enables a systematic approach to understanding the sector as a whole and more targeted supports and interventions to be devised to support the development of each activity.

There are specific characteristics that set tourism in coastal and marine areas apart from other maritime sectors. The sector includes a large number of micro-SMEs and family businesses, inherent seasonality, access to labour, insecure employment, and often tight margins. Among other pressures, many of these businesses are increasingly exposed to the impact of climate change and extreme weather events which can directly impact their cost-base, viability and in extreme cases, their survival. Tourism businesses are not generally set up to support in-house research and innovation in the way, for example, a high-tech start-up might be. Determining the research knowledge gaps and needs can, therefore, be challenging, but there are undoubtedly opportunities for businesses to innovate, to leverage data and information, to apply technologies to reduce costs and increase efficiencies, and to

[28] Northrop, E. et al., 2022. Opportunities for Transforming Marine and Coastal Tourism: Towards Sustainability, Regeneration and Resilience. Special report of the High-Level Panel for a Sustainable Blue Economy.
[29] Ireland's Ocean Economy, 2023. http://hdl.handle.net/10793/1882
[30] 10 Years of the Wild Atlantic Way. A Decade of Transformational Tourism Impact on the West Coast of Ireland.
[31] A Survey of Domestic Coastal and Marine Tourism and Leisure Activity in Ireland.
[32] A Survey of Marine and Coastal Overseas Tourism Activity in Ireland.

move towards more sustainable and resilient business models. By collaborating and sharing knowledge, businesses and communities can accelerate progress even further.

The mid-term review of the previous National Marine Research & Innovation Strategy (2017-2021)[33] demonstrated a low level of investment in the theme Tourism and Leisure, one of 15 marine thematic areas covered by the strategy. The national research capability was also reported to be low, with a limited number of active researchers/experts within the national system, and those that were active were not well coordinated or networked internationally. The level of RDI investment was also relatively low, with no dedicated calls or programmes and no national infrastructures or test-beds in place. In short, the level of RDI capacity and investment support of one of our most important marine sectors is minimal, limiting in turn the opportunities for innovation and sectoral development.

**Research, Knowledge and Innovation Priority Areas**

A core goal for this strategy must be to raise the national capacity and level of RDI investment in RDI supporting coastal and marine tourism. Research in this area is needed to guide policy and planning to support a just and efficient transition towards more low-impact, regenerative tourism. This will require greater coordination between development agencies and research funders and the establishment of specific targets in relation to programming, funding, expertise and capacity build. Some of the key areas where RDI is needed are outlined below.

1. Increasing resilience

RDI to enable coastal tourism operators to make evidence-based decisions and investments on protecting infrastructure and assets, early warning and appropriate response to extreme weather events and planning for the longer-term impacts of climate change.

Research to understand how unique coastal ecosystems are impacted by and interact with pressures from coastal and marine tourism activities and businesses, combining natural and social science expertise.

2. Understanding the sector and its drivers

Consumer-focused research to assess views, attitudes and behaviours of domestic and overseas tourists to understand consumer expectations, perceptions and guide innovation in future tourism offerings.

Research on marketing Ireland as an attractive tourism destination (e.g. recent 10-year anniversary report on the success and sustainability of the Wild Atlantic Way).

Research to better understand the drivers and pressures facing those operating tourism businesses and their outlook for future development of their businesses.

[33] Interim Review of the National Marine Research & Innovation Strategy 2017-2021. http://hdl.handle.net/10793/1692

Further assessment of the economic output of the sector and its constituent activities, at national and sub-national (regional or county level) to guide public policy, governance, planning and investment programmes.

3. Innovating for new opportunities

RDI to inform the development of new tourism products, for example the further development of eco-tourism and citizen science activities which provide attractive touristic offerings and leverage the value of Ireland's extensive natural capital and maritime heritage.

Working with established and emerging sectors to provide tourism opportunities linked to offshore energy installations, aquaculture operations, fisheries, and ports.

Research to understand better the social, cultural and historical connections between Ireland's offshore islands, their distinctive biodiversity and the opportunities they provide for more integrated tourism.

4. Exploiting marine data, products and services, and new technologies

Using the availability of open access marine data, data products (e.g. visualisation, maps) and services (live data portals) to inform tourism operations (e.g. tidal and wave conditions, areas vulnerable to coastal hazards such as landslides, erosion or acretion) and to enable new or previously unexploited opportunities for example in eco-tourism, wildlife tracking, and maritime heritage including the extensive information on ship-wrecks provided through the INFOMAR seabed mapping programme.

RDI to explore the establishment of digital platforms to enable tourism operators and coastal businesses to share knowledge, skills and best practices and enable collaborative product development.

5. Transition to sustainable zero carbon business models

Solutions-focused RDI to enable marine and coastal tourism providers to reduce the environmental impact of their operations and transition to sustainable business models, in line with the Fáilte Ireland Climate action programme[34]. This can include for example the electrification of ground transportation and recreational vessels, reduction of waste streams and improving coordination between operators and co-existence between activities and sectors.

**Key Actions 2025-2026**

| Action | Implementation |
|---|---|
| 24. Establish a dedicated cross-agency research programme to address key challenges linked to a just and efficient transition to a sustainable, climate-neutral and resilient coastal and marine tourism (in line with broader coordination efforts in coastal policy set out in the report of | FI, DHLGH, |

[34] https://www.failteireland.ie/climateactionprogramme.aspx

| Action | Implementation |
|---|---|
| the Inter-Departmental Group on National Coastal Change Management Strategy35). | |
| 25. Promote the development of a specific work stream on coastal and marine tourism within EU programmes with corresponding support to transnational calls and RDI investment. | MI |
| 26. Conduct an assessment of the energy usage and needs across marine and coastal tourism and propose viable policy and strategies and measures for reducing sectoral energy use and green-house gas emissions. | Marine Research Funders' Forum |

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[35] Report of the Inter-Departmental Group on National Coastal Change Management Strategy (October 2023)

## 4.5 Safe and secure seas

The period up to 2050 will see a potentially five-fold increase in the usage of Europe's maritime space by offshore installations for energy and food production[36]. This rise in activity will bring with it increased risks to safety of navigation, pollution incident risk, increased demands on search & rescue services, and vulnerability to nefarious interference. Protection of strategic maritime interests, natural and other resources, and maritime infrastructure is fundamental to the sustainable development of a maritime economy and the meaningful assertion of sovereignty as a coastal state.

The major planned expansion of Ireland's offshore renewable energy sector, in particular, will lead to a significantly greater number of strategically, economically and environmentally important assets and critical national infrastructures off Ireland's coasts that must be protected from harm. If we meet our 2030 and 2050 renewable energy targets, Ireland also has the potential to become a major generator of clean energy for the European continent, raising further risk of interference, damage or attack by rogue actors.

Even in advance of the large-scale deployment of offshore renewable energy installations, there is an imperative to provide effective oversight and security of existing offshore assets, particularly those on the seabed such as energy pipelines, interconnectors and power & telecommunications cables[37]. Ireland's strategic position as a gateway from northern Europe to the Atlantic means that around three-quarters of all telecommunications cables in the northern hemisphere pass through or near Irish waters[38]. The associated security requirements also present legal and governance challenges, as subsea cables generally have shared ownership and are not the property of a single state.

Monitoring the maritime domain – including the air, surface and subsea - is a critical enabler to provide government, state agencies and other organisations with data, knowledge and intelligence to support effective management and decision-making for maritime safety and security purposes. Our maritime space is already subject to substantial monitoring through operational programmes linked, for example, to weather and climate services; EU marine, water and nature directives; intergovernmental commitments such as OSPAR; and scientific programmes; but Ireland's capabilities in this area are currently fragmented and are operating in a governance, legal and regulatory environment that is unclear.

Substantial opportunities exist, both for the state and for private sector actors, in the areas of maritime security, cybersecurity, advanced ocean technologies, offshore engineering, navigation technologies, data exchange and data analytics, metocean monitoring and forecasting, seabed and coastal monitoring and digital products and services. Ireland already holds extensive expertise in its technology sector. As of 2024, 16 of the top 20 global tech companies and the top three enterprise software providers are located in Ireland, as well as

[36] S S Pettersen et al 2023 J. Phys.: Conf. Ser. 2507 012005

[37] https://www.hybridcoe.fi/

[38] Robert McCabe & Brendan Flynn (2024) Under the radar: Ireland, maritime security capacity, and the governance of subsea infrastructure, European Security, 33:2, 324-344, DOI: 10.1080/09662839.2023.2248001

six of the top ten cybersecurity firms (2021). There is, therefore, an opportunity to leverage the value of these Irish-based technology companies and expertise to apply cutting edge technologies and advancements to multiple safety, surveillance and security challenges. Progress in meeting all of these challenges and opportunities should be supported by RDI across these technical and engineering domains but also in the natural sciences, climate science, ocean policy and governance, marine/environmental economics, social sciences and humanities.

**Research, Knowledge and Innovation Priority Areas**

- Increased research in the areas of ocean governance, policy and planning, focusing for example on trade-offs, scenario building and testing to inform decision-making on marine spatial planning, consenting, licencing and co-existence of sectoral activities, maritime safety, surveillance and search and rescue functions.
- Assessments of and response options to cyber and hybrid threats to offshore and coastal infrastructures, essential safety infrastructure and assets to ensure safe navigation, to inform prevention and emergency response planning.
- Assessment of defence and security threats and response options for the protection of critical national and underwater infrastructure to act as a deterrent or to mitigate potential risks and challenges in the maritime domain.
- Enhanced capacity for using big data analytics approaches supported by high-performance computing to inform complex interactions between environmental, climate and sectoral activities.
- Assessment of the cumulative impact of ORE development and Offshore Wind Farms (OWF) on navigation, safety and sea traffic management.
- Exploration of future systems to integrate radio navigation, radio communication and emerging technologies including further harmonisation and interoperability of maritime information and navigation technologies to ensure maritime safety, efficient transport and environmental protection.
- Increased oceanographic modelling and predictive tools and capacities to inform optimum deployment of offshore installations, ship routing, operational and maintenance support and search and rescue.
- RDI focused on understanding the risks and impacts arising from climate change and extreme weather and sea state conditions on surface, water column, seabed and sub-seabed installations. and associated adaptation mechanisms.
- Application to maritime safety and security goals of a shared data-centric High-Performance Computing (HPC) Platform coupled with federated data spaces with advanced analytical tools that will enable digital twin approaches to addressing maritime safety and security challenges and threats.

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- Social science and humanities research to better understand public attitudes towards safety and security threats and acceptance of the substantial change in the use of marine space and coastal ports and infrastructures.

**Key Actions 2025-2026**

| Action | Implementation |
|---|---|
| 27. Evolve and expand the provision of land-based, near- and offshore test and demonstration facilities for use by state agencies and technology developers for testing marine engineering devices and prototypes. Optimise applications and use of existing platforms such as offshore marine observation and data buoys and aids to navigation. | SEAI, MI, IL, INS, ME |
| 28. Assess mitigation actions and interventions to counter navigational risks as well as newly emerging technical mitigations (e.g. e-Navigation services for traffic de-confliction) linked to rapid and large-scale deployment of ORE in Ireland's maritime area.<br>Develop tools, models and analysis over wide areas up to national scale to understand how new wind farm developments will change the pattern of maritime risk and to guide the provision of new services or other processes (e.g. regulatory and routeing) to mitigate navigational safety risks. | DECC, MI, DoT/MSO, IL, SEAI, MARA, MI, ORE Industry bodies |

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# 5. Enablers for Ocean Knowledge

Successful implementation of the actions set out in this strategy will require sufficient capacity and capability across the research and innovation system. Impact 2030, as the over-arching national Research and Innovation strategy, addresses a wide range of strategic challenges and goals linking the growth and development of our national research, knowledge and innovation (RKI) system, structures and processes to delivery of research excellence and beneficial societal impact. As marine and maritime RKI forms a subset of the broader national R&I effort, many of these systemic issues (e.g. PhD training, challenge-based funding, open research) are fully relevant in the context of achieving the goals of this strategy and will not be repeated here.

Ocean Knowledge 2030 focuses on those aspects of the public RKI system and structures that are specifically relevant to marine and maritime RKI. In particular, there is a need to identify gaps and future needs for an efficient and impactful RKI system linked to marine policy and sectoral demands and to set out a limited set of strategic actions to ensure that these are addressed within the broader framework of Impact 2030. These are framed here as 'Enablers' as they are critical to enable delivery of the Ocean Knowledge 2030 strategy, and are presented under five headings:

- Training, Talent and Expertise
- Marine Research Infrastructures
- Data and Digitalisation
- Partnerships, Networks and Connectivity
- Funding & Investment

## 5.1 Training, Talent and Expertise

Human capacities are a critical component of the broader capacities needed to underpin an effective and responsive RKI system. Human capacity refers to development of and access to researchers and domain knowledge and expertise within the system, capable of responding to societally-relevant RKI challenges. This can range from successful internship programmes for third-level students to leveraging the expertise of leading academics at the peak of their career. The COVID-19 pandemic illustrated the importance of building and retaining human capital with critical knowledge and expertise within the national system, both to conduct research needed to address future challenges, and to ensure that there is a knowledge-based response to societal challenges.

Across multiple marine and maritime sectors, employment, careers and skills opportunities are evolving rapidly, with the planned installation of offshore renewables as one notable driver. The forthcoming changes in how we utilize our marine space will require multi-disciplinary solutions and graduates with knowledge and skill sets to meet the needs of employers and to solve complex challenges that cut across areas such as marine ecology, marine environment and metocean monitoring and assessment, physical oceanography,

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marine engineering, maritime law and governance, data science, social and economic sciences and more. It will also require a greater number of graduates with the right qualifications to meet the growing demand across sectors such as blue bioeconomy, offshore renewable energy, marine engineering, or marine ecology. Our graduates of the future need to be provided with multi-disciplinary training, combining specialist learning in one discipline with a broad understanding of ancillary subject areas that enable problem-solving, innovation and entrepreneurship.

A key consideration is the perception of marine and maritime as a legitimate and recognized career pathway that appeals to school-leavers and early career professionals alike. Greater national coordination in the provision of placement and internship opportunities within marine companies and public bodies will also be important to give hands-on experience to students in secondary and tertiary education and to guide and inspire their career choices.

**Key Actions 2025-2026**

| Action | Implementation |
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## 5.2 Marine Research Infrastructures

The ocean is an exposed and unpredictable research arena that is costly to access. Research infrastructures provide the mechanism for scientists to interact with and study the marine environment, and are an essential enabler for marine and maritime research and innovation. *In situ* ocean observing infrastructures such as data buoys. Argo floats, cabled observatories, deepwater moorings, GLOSS[39] and tide gauges enable the collection of oceanographic, climate and metocean data and information, underpinning scientific research and evidenced-based policy and management. Laboratories, test and demonstration facilities and digital infrastructures are also part of the national stock of marine research infrastructures. The research vessels, the RV Celtic Explorer, RV Tom Crean (Marine Institute), RV Ray Keary (GSI) and a range of smaller inshore vessels are critical to provide access to coastal and oceanic and coastal environments for academic and government scientists.

The Marine Institute's *Compendium of Marine Research Infrastructures in Ireland* report (2022)[40] provides a catalogue of 164 national infrastructures and large equipment owned and operated by 21 different organizations, including government bodies and Higher Education Institutions. A key challenge is to ensure that infrastructures, observing platforms and large equipment are available to researchers in a way that promotes research excellence and impact. Impact 2030 recognizes the importance of research infrastructures as 'a critical element of an enabling R&I environment' and emphasizes the need to make them as accessible as possible to researchers across the system. It commits to a number of actions leading to a framework for future capital investment in research infrastructure. It will be

[39] Global Sea Level Observing System
[40] A Compendium of Marine Research Infrastructures in Ireland. Marine Institute, 2022. ISBN 978-1-902895-77-2

important to ensure that the specific challenges and opportunities for future advancement of marine research infrastructures are well reflected in this broader exercise.

Ireland also engages proactively with EU projects and policy platforms on (marine) research infrastructures which are important to support knowledge exchange and best practice in the development, operation and management of strategically important infrastructures and to provide opportunities for access of Irish researchers to international infrastructure platforms and of overseas researchers to access Irish facilities.

Looking ahead to 2030 some particular challenges include enabling optimum access conditions for researchers to national and international research infrastructures; ensuring that the research infrastructure base takes advantage of technological advancements (e.g. underwater robotics and autonomous underwater vehicles, machine-to-machine learning, eDNA monitoring technology, etc.); and ensuring that planning and permitting for test and demonstration facilities enables their rapid deployment in response to identified needs. A notable goal is development of the planned Offshore Wind Centre of Excellence, a specific action under *Powering Prosperity*[41].

**Key Actions 2025-2026**

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## 5.3 Data and Digitalization

Ireland's national digital strategy, *Harnessing Digital – The Digital Ireland Framework*, was launched in 2022 to drive and enable the digital transition across Ireland's economy and society. Data and digitalisation are central to the delivery of government and public services and to the generation of new opportunities for enterprise and innovation.

Marine science, management and enterprise are rapidly entering the digital age. An ever-increasing flow of data from *in situ* ocean observing platforms, automated sampling and smart sensors provides opportunities to transform the way we study and understand the ocean and offers new approaches for the management of marine resources[42]. In addition, the volume and breadth of space (satellite) data, freely available through our membership of both the EU and the European Space Agency, offers significant opportunities. Space enabled technology and datasets can provide policy makers and maritime businesses with critical information and evidence in areas such as navigation, weather, maritime safety and security.

While substantial data systems and assets are in place, it is becoming clear that there is a deficit in the required coordination across organisations and programmes both at national level and in terms of Ireland's participation in international data and observation

[41] https://enterprise.gov.ie/en/publications/powering-prosperity.html

[42] Guidi, L., et al. (2020) Big Data in Marine Science. Future Science Brief 6 of the European Marine Board, Ostend, Belgium. ISSN: 2593-5232. ISBN: 9789492043931. DOI: 10.5281/zenodo.3755793

programmes. A coordinated and federated national marine evidence base, with usable scientifically validated marine data and associated digital capabilities, is now needed to support research, innovation and decision making for marine policy and management (e.g. mapping opportunities and constraints for Designated Marine Area Plans or DMAPs).

Realising a national, open access marine evidence base requires access to high-quality marine data from a wide range of sources, combined with the expertise and technologies to interpret the data and convert it into usable information. This requires data integration; data analyses and product development; data management and quality control; and user-focused visualisation and analyses tools. The application of new data standards and tools (e.g. cloud-optimised data lakes), and enhanced user-focused analytics tools (e.g. 3D spatial tools), allow for these data to be more readily applied to policy making, for marine management and for a broader understanding of our marine environment.

Gaps in the data and information (e.g. data on inshore fisheries) also need to be identified and addressed, while other data which has high potential value e.g. aerial remote sensing and high-resolution seabed data, can be difficult for stakeholders to access and use.

With the increasing availability of artificial intelligence there is also potential to better understand what is happening in our marine space through enhanced analyses of "big data" including very large data sets, the enhancement of predictive models, and the analysis of streaming data (e.g. video or acoustics). The adoption of artificial intelligence capabilities is dependent on well-defined processes, artificial intelligence models and underpinning trusted data.

This broadening of the access to usable and trusted marine information will become increasingly important for marine planning, licensing and development, for marine operations, for environmental management, and for climate adaptation.

**Key Actions 2025-2026**

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## 5.4 Partnerships, Networks and Connectivity

Partnerships and networks provide a mechanism for individual researchers, research groups, institutions or the State to participate in and interact with peers and counterparts at multiple spatial scales (sub-national, national, regional/sea basin, EU and international). Across the marine R&I and ocean policy system, there is a complex array of such networks and partnerships, both formal and informal, with a diversity of scope and functions including the exchange of knowledge and best practice, direct collaboration on research projects and programmes, joint training, influencing and setting research policy and agendas, co-funding of research, and/or delivery of tangible products and services to advance common R&I goals.

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At sea basin, EU and international level, Ireland already participates in numerous networks and partnerships and such participation delivers benefits which can sometimes be explicit and measurable but are often less tangible but no less valuable. The term 'science diplomacy' has emerged in recent years to encapsulate the value of international engagement, dialogue and cooperation through science and by scientists (also relevant for non-scientific disciplines). For a small country like Ireland, the deployment of soft power to counterbalance the influence of much larger countries that can deploy more resources and personnel is an important and ongoing responsibility and one where, in the context of marine R&I, we generally perform well.

Nonetheless, it will be critical for Ireland to remain influential in the international arena by ensuring pro-active and targeted participation and leadership by experienced personnel with a clear mandate to act on behalf of the state. Increased recognition of the role and expertise of a national cohort of research and ocean policy professionals based in government departments and agencies is important to ensure that early career professionals see the value of these positions as attractive career opportunities.

Our researchers are key in developing and maintaining influence and cooperation through partnerships and networks at national and international level and should be provided where possible with programmatic supports to travel and participate. Award schemes that provide small sums of money to support travel and networking are often highly impactful in underpinning research cooperation and the building of partnerships. Under Impact 2030, a number of flagship initiatives are included on "All-Island, EU and Global Connectivity" including Ireland's participation in the European Research Area (ERA). The All-Island and UK-Ireland dimensions are of particular importance given the marine science and management challenges that are shared by neighbouring jurisdictions and the impact of Brexit on the lost opportunities for cooperation through EU programmes such as Interreg.

**Key Actions 2025-2026**

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## 5.5 Funding and Investment

[To be completed]

**Key Actions 2025-2026**

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# 6. Optimizing Implementation and Impact

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