

# National Marine Research & Innovation Strategy 2017–2021





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# Our Ocean Resource

**Foreword by Michael Creed T.D.,  
Minister for Agriculture, Food and the Marine**


Publication in 2012 of *'Harnessing Our Ocean Wealth'*, Ireland's first national Integrated Marine Plan, ushered in a dramatic period of change for Ireland's marine sector. It has underpinned much of the work carried out by the Inter-Departmental Marine Coordination Group, which I chair, and has brought about a renewed focus by the State on the value of the marine sector to the Irish economy and to Irish society generally. It and the Programme for a Partnership Government recognise the value of Ireland's marine asset in economic, environmental and cultural terms.

Among the many issues identified by the Plan was the need for a strategic marine research and innovation agenda to promote cross-agency collaboration. The importance of Ireland's marine resources is further emphasised by the identification of research and innovation in the sustainable development of the marine in *Innovation 2020*, Ireland's national research and innovation strategy, published by the Minister for Jobs, Enterprise and Innovation.

This new Marine Research and Innovation Strategy marks a further step forward. The Strategy has been developed by the Marine Institute on behalf of the various Government Departments which participate in the Marine Coordination Group. The intention of the Strategy is that the outputs of new research and innovation are combined with existing knowledge to generate value within the marine economy. The Strategy focuses on the broad

topics identified in existing Government policies and strategies and provides a framework which recognises the complexity of research funding in the marine domain. This framework recognises that a range of Departments and State Agencies are involved in funding in the marine research area but does not aim to be prescriptive on how those bodies use that funding. Rather it provides insights as to where such investment can have maximum impact and yield best value for money for the State. The Strategy also advocates the future joint funding of projects by two or more Agencies in order to make a significant impact on marine research capacity in Ireland, leading to greater potential yields of research funding from European sources.

Increasingly "the marine" is being woven into the fabric of Ireland's national economic, scientific and environmental policy and in recent years the concepts of "innovation" and "the marine" have often been interlinked – both were identified as crucial aspects of Ireland's economic recovery as we work to increase our competencies in Science, Technology, Engineering and Mathematics (STEM). Investments by agencies such as Science Foundation Ireland (SFI) in the MaREI and iCRAG Research Centres are examples of Ireland's commitment to raise STEM capacity through innovation and the marine. In parallel, there has been a significant increase in the level of investment in targeted marine research in recent years.



Irish marine researchers have been very successful in attracting support for projects at the cutting edge of ocean research. For example, over three years of the EU research programme Horizon 2020, Irish marine researchers have won a total of €24.9m across all pillars and instruments of the current framework programme. This represents 6.5% of the total research funding awarded to Ireland under this programme so far. It is indicative of a pattern of rising investment in marine related research which will in time yield substantial benefits to Ireland's wider economy and to our citizens, through increased employment opportunities.

These investments and successes reflect the excellence of the research and the strategic relevance of the sector to industry and Ireland. Publication of this National Marine Research and Innovation Strategy will bring us even closer to achieving the actions set out in both *Harnessing Our Ocean Wealth* and *Innovation 2020*. Its publication reflects the recognition in both documents that continued investment in marine research is central to the realisation of the benefits from our marine resource for all of Ireland's citizens.



# Ireland, Science and the Sea

**Foreword by Dr Peter Heffernan,  
CEO of the Marine Institute**

In 1974, the National Science Council published “Ireland, Science and the Sea – A Programme for Marine Science and Technology in Ireland”. The report was prescient, as many of its recommendations have come to pass. Irish researchers can now venture from sight of the shore on board the RV *Celtic Explorer* and the RV *Celtic Voyager*. The Marine Institute has been established and has found a home with state-of-the-art laboratories in Galway. Ireland is now a world leader in the field of seabed mapping through the expertise of the Geological Survey of Ireland and the Marine Institute, while Cork has become a centre for maritime and nautical development through institutions such as the National Maritime College of Ireland and the Beaufort Research Laboratory.

Since the 1974 report, Ireland has continuously set itself goals for marine research, most recently in the form of *Sea Change* in 2007. This saw a detailed foresight exercise which remains largely valid. The impact of these goals can be seen in Ireland’s international research performance; Irish researchers regularly win far in excess of their ‘juste retour’ from European Union competitive funding.

In the years since 2007, the Irish science, research and innovation landscape has changed significantly. Through the work of Science Foundation Ireland (SFI), Ireland has risen rapidly in international science impact rankings. The Higher Education Authority has overseen unprecedented levels of investment in research infrastructure. The Irish Research Council (IRC) is investing in researcher excellence in a broad range of disciplines. Most significantly, through the national research prioritisation process and culminating in the publication of *Innovation 2020*, there is a high degree of coordination in the State’s approach to research funding. As a consequence of this, and Ireland’s increasing marine research capacity, research funding for marine topics now comes from a variety of sources. Basic research, in particular, is supported on the basis of research excellence by SFI and the IRC. This Strategy therefore sets out to support all funding agencies by providing insights into how their resources can best be employed in the area of marine research. It also is intended to inform research performing institutions as to where the most impact can be achieved.



The marine policy landscape has also evolved significantly over the last decade, mirrored at both EU and national level. Key milestones include the development of Integrated Maritime Policy by the EU (and related initiatives such as its Blue Growth Strategy) and nationally the publication in 2012 of Ireland's first integrated marine plan – *Harnessing Our Ocean Wealth*. Spearheaded by the Interdepartmental Marine Coordination Group, Ireland is putting in place a range of integrated enabling actions to achieve the goals and ambitions set out in *Harnessing Our Ocean Wealth*. A number of these actions are focused on research, knowledge, technology and innovation.

Of crucial importance in the ongoing evolution of Ireland's marine research capacity will be the integration of expertise from areas previously unconnected to the marine sector. This reflects the concept of "marinising" introduced by the report of the Development Task Force. By encouraging interaction between disciplines, the marine sector can benefit from Ireland's wider research talent pool and research infrastructure.





# Statement of Strategy

Marine research is cross-cutting in nature. This is highlighted in the National Research and Innovation Strategy, *Innovation 2020*, which positions marine as one of a number of societal challenge areas. This National Marine Research and Innovation Strategy has identified a number of marine-related research themes. There are a range of agencies and government departments that have a role in the promotion and funding of marine research in relation to these themes, such as food, energy, transport and biodiversity. In addition, there are a range of agencies involved in enterprise development and science promotion that also have a significant role to play.

In defining a funding strategy for marine research, an objective is therefore to utilise the existing range of supports provided by these agencies (where marine research themes compete on their own merits).

The **first goal** articulated by this strategy is to **raise the research capacity** across all themes.

The **second goal** articulated by this strategy is that **research funding should be targeted**, within the overall goal of raising research maturity, to topics matching requirements articulated in state **policies and sectoral plans**. Speculative research, in the absence of clear capacity building or sectoral development goals, should only take place in the context of promoting research excellence.

The **third goal** is that there should be **coherence in the approach to marine research by the various state actors** involved in funding

marine research. This coherence should be achieved by reference to this strategy and carrying out the specific roles laid out below.

The research themes identified in this strategy are also strategically important in supporting Ireland's goals to deliver economic, societal and environmental sustainability. Accordingly, they are classified under the three goals of *Harnessing Our Ocean Wealth – A Thriving Maritime Economy, Healthy Marine Ecosystems and Engagement with the Sea*.

The approach taken in this strategy is not to prioritise any one of these themes above the other; it is recognised that inter-dependencies and synergies exist across a number of them. The strategy seeks to simultaneously support the development of Ireland's overall marine research capacity, focusing on the research needs as already articulated in relevant policies, plans and strategies.



# Introduction

This document sets out Ireland's Marine Research and Innovation Strategy for the period up to 2021. It builds on the significant progress made during the implementation of Ireland's previous Marine Research, Knowledge and Innovation Strategy – *Sea Change 2007-2013*, which added new research capacity in priority areas and highlighted the potential of marine-related research to contribute to wider economic growth. Significant progress has been made since 2007, with marine research moving from what was considered by some as being a niche field to being a theme that pervades much of the fabric of Irish research effort.

## Research Themes

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As part of the preparation process, a review of the major policy drivers that exist at a national and international level has identified 15 research themes (a number of which have sub-themes), as illustrated in Figure 1.

The approach taken is not to prioritise any one theme above another; it is recognised that inter-dependencies and synergies exist across a number of them. The strategy seeks to simultaneously support the development of Ireland's overall marine research capacity, focusing on the research needs as articulated in relevant policies, plans and strategies.

In developing this strategy, each of the 15 research themes has been the subject of an objective review. These reviews have sought to establish:

- the drivers for research in each theme;
- the capability that exists to meet these drivers; and
- the appropriate interventions required on the part of the state to address any gaps that exist.

## Research Drivers

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To ensure that the strategy is focused on applied and demand-led research, the research requirements for each theme are drawn from pre-existing plans, policies and strategies (sectoral and cross-cutting). The strategy also recognises the importance of a fully functional marine research system that extends from basic to applied research.

Figure 1: Cross-Cutting National and International Policy Drivers

	EU Integrated Maritime Policy	EU CFP – EMFF OP 2014-2020	JPI Oceans R&I Agenda	EU Strategy for the Atlantic & Action Plan	Harnessing Our Ocean Wealth	Our Ocean Wealth Development Task Force	Innovation 2020	National Research Prioritisation	Enterprise 2025
<b>A THRIVING MARITIME ECONOMY</b>									
<b>Bioresources</b>									
› Aquaculture & Biomass Production									
› Wild Resources	√	√	√	√	√	√	√	√	√
› Processing for Food & Other Use									
› High Value Products									
<b>Advanced Technologies</b>	√		√	√	√	√	√	√	√
<b>Subsea Resources</b>	√		√	√	√	√			√
<b>Renewable Energy</b>	√			√	√	√	√	√	√
<b>Tourism &amp; Leisure</b>	√			√	√	√			√
<b>Transport &amp; Logistics</b>	√			√	√	√			√
<b>Security &amp; Surveillance</b>	√	√		√	√	√	√	√	√
<b>HEALTHY MARINE ECOSYSTEMS</b>									
<b>Biodiversity, Ecosystems &amp; Food-webs</b>	√	√	√	√	√		√		
<b>Pollution &amp; Litter</b>	√	√		√	√				
<b>Climate Change</b>	√	√	√	√	√		√		
<b>Ocean Observation &amp; Seabed Mapping</b>	√		√	√	√	√	√		
<b>ENGAGEMENT WITH THE SEA</b>									
<b>Ocean Literacy &amp; Education</b>	√	√		√	√				
<b>Integrated Policy &amp; Governance</b>									
› Socio Economics									
› Law	√	√	√	√	√	√			√
› Planning & Governance									
› Business Development									
<b>Information &amp; Spatial Technologies, Analytics and Modelling</b>	√			√	√	√	√		√
<b>Engineering</b>	√			√	√	√	√	√	√

# Research Maturity Capability Assessment

The strategy complements and builds on other national research and innovation strategies, such as **National Prioritisation Exercise** and **Innovation 2020**, and recognises the wide range of supports and interventions that the state as a whole has at its disposal. In order to enable the best use of those supports, this strategy evaluates research capability using a model developed by the Marine Institute as part of the preparation of this strategy. This model has three broad dimensions:

- Human Capacity;
- Infrastructure; and
- Networks & Relationships.

Each of these dimensions is considered in relation to one of five levels of capability/maturity, ranging from “Ad-hoc” through to “Translational”, as shown in Figure 3.

Figure 2 gives a general description of what would represent a particular level of maturity in a thematic area. Within each of the dimensions, more specific indicators of maturity have been developed that allowed the maturity level to be assessed (see Figure 3).

This approach is intended to focus future research support effort on where it can have most impact and allows a consistent view to be taken across the themes considered by the strategy. The assessment of each theme is a national one with the objective being to strengthen Ireland’s research capacity as a whole in order to deliver on our national priorities.

Figure 2: Research Capability Maturity Model

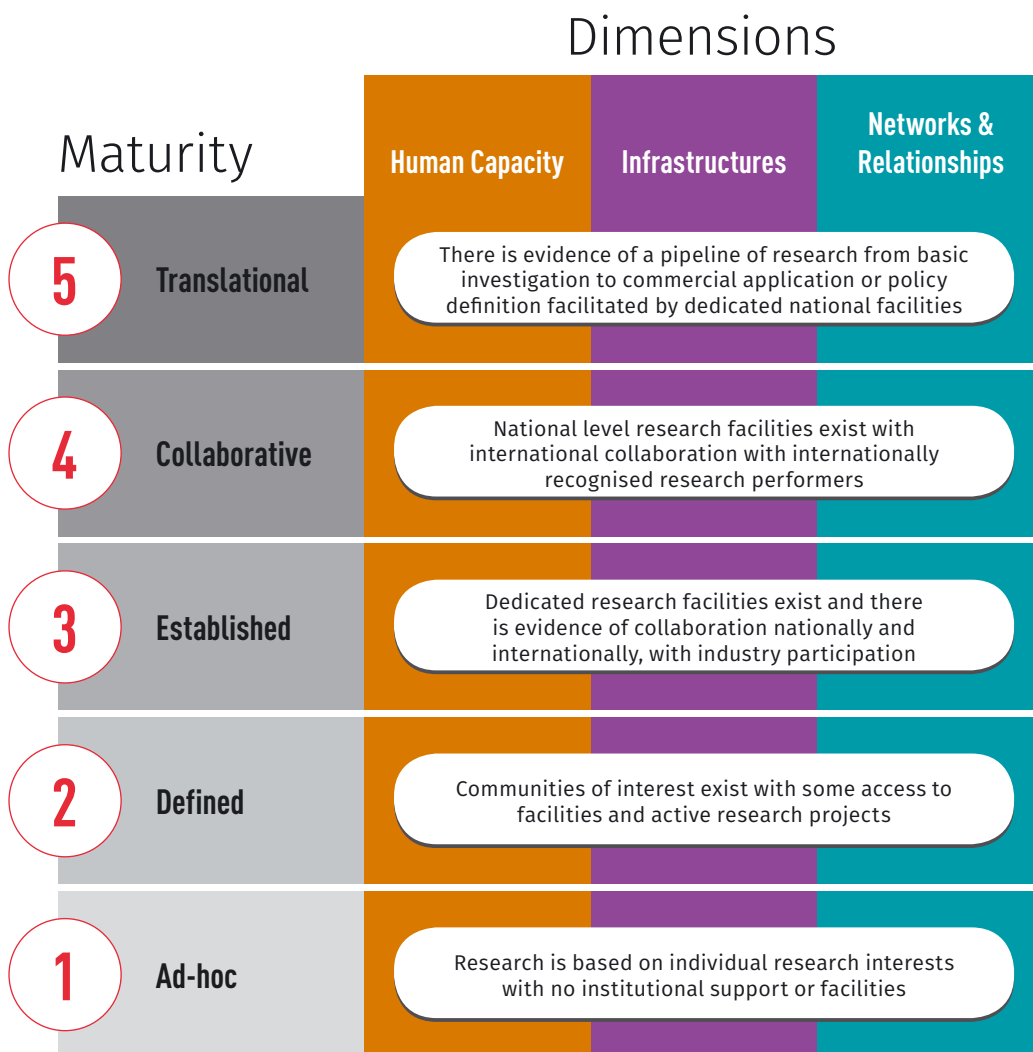


Figure 3: Research Capability Maturity Model

Maturity	Human Capacity
<p><b>5</b></p> <p><b>Translational</b></p> <p>There is evidence of a pipeline of research from basis investigation to commercial application or policy definition facilitated by dedicated national facilities.</p>	<ul style="list-style-type: none"> <li>› Industry based researchers involved in Product Development Lifecycles.</li> <li>› Researchers participating in legislatively based, or ministerial appointed, fora that inform legislation or regulation.</li> </ul>
<p><b>4</b></p> <p><b>Collaborative</b></p> <p>National level research facilities exist with international collaboration with internationally recognised research performers.</p>	<ul style="list-style-type: none"> <li>› International Research Awards, e.g. ERC Research Awards.</li> <li>› International Travel Awards, e.g. Fulbright.</li> <li>› International Research Contracts e.g. EU Tender Awards.</li> <li>› Regular development or refinement of methods, techniques or processes that inform regulation.</li> </ul>
<p><b>3</b></p> <p><b>Established</b></p> <p>Dedicated research facilities exist and there is evidence of collaboration nationally and internationally, with industry participation.</p>	<ul style="list-style-type: none"> <li>› Established Principal Investigator Position(s).</li> <li>› PI Led Research Teams with Postdoctoral Researchers.</li> </ul>
<p><b>2</b></p> <p><b>Defined</b></p> <p>Communities of interest exist with some access to facilities and active research projects.</p>	<ul style="list-style-type: none"> <li>› Multiple Project Based PI Appointments.</li> <li>› Active PhD Level Research Projects.</li> <li>› Undergraduate courses with established lecturers.</li> </ul>
<p><b>1</b></p> <p><b>Ad-hoc</b></p> <p>Research is based on individual research interests with no institutional support or facilities.</p>	<ul style="list-style-type: none"> <li>› No dedicated facilities, general purpose equipment etc.</li> <li>› No dedicated training or education associated with the field.</li> </ul>



# Dimensions

## Infrastructures

- › Nationally funded research centres.
- › Postdoctoral Training.
- › EU “Best in class” research infrastructures.
- › National Test & Demonstration Facilities, including end-user population for real-world feedback.

- › Nationally available equipment or platforms (e.g. equipment pools).
- › Postgraduate training.
- › Participation in EU infrastructure networks.
- › National Test and Demonstration facilities.
- › Postdoctoral training.

- › Purpose built lab space/purpose bought equipment.
- › Dedicated data infrastructures or repositories.
- › Postgraduate teaching modules and/or courses.

- › Defined undergraduate training.
- › “Allocated” general purpose lab space or equipment, evidence of institutional commitment through capital spending.

- › No dedicated facilities or general purpose equipment etc.
- › No evidence of commitment through capital spending.

## Networks & Relationships

- › Networks of interest featuring high levels of industry or policy-making participation.
- › IP frameworks available.
- › Consistent leadership roles in international standard setting forums.
- › Consistent leadership roles in international inter-governmental mandated scientific organisations.

- › Inter-institutional research cluster/centres.
- › Industry collaboration in research including industry funding.
- › Industry participation in research theme definition.
- › Funding from policy-making organisations.

- › Multiple teams concurrently participating in Framework/H2020 projects.
- › Industry or sectoral policy-maker led research themes.
- › Regular national conferences/workshops with some international participation.

- › National Workshops.
- › Inclusion in Framework/H2020 bids.
- › Recognised community of interest.

- › No nationally organised/hosted workshops.
- › No associations, networks of interest.
- › Collaboration is based entirely on one-to-one or personal relationships.



# Analysis of Research Themes

As referred to in the Introduction, the process of preparing this strategy has included the identification of 15 key research themes based on the major marine-related policy drivers at a national and European level.

The following section provides an overview of each of these themes in terms of research maturity associated with the theme, research requirements identified in sectoral plans or government policies, a list of targeted actions and focus of funding required to raise the research maturity across three dimensions of human capacity, research infrastructures and networks & relationships.

These overviews across the 15 themes were derived from a number of in-depth discussion documents. A copy of the full analysis is available as a back-up to this strategy.

## A THRIVING MARITIME ECONOMY

### Bioresources

- › Aquaculture & Biomass Production
- › Wild Resources
- › Processing for Food & Other Use
- › High Value Products

### Advanced Technologies

### Subsea Resources

### Renewable Energy

### Tourism & Leisure

### Transport & Logistics

### Security & Surveillance

## HEALTHY MARINE ECOSYSTEMS

### Biodiversity, Ecosystems & Food-webs

### Pollution & Litter

### Climate Change

### Ocean Observation and Seabed Mapping

## ENGAGEMENT WITH THE SEA

### Ocean Literacy & Education

### Integrated Policy & Governance

- › Socio Economics
- › Law
- › Planning & Governance
- › Business Development

### Information & Spatial Technologies, Analytics and Modelling

### Engineering



# A Thriving Maritime Economy

The first goal of Harnessing Our Ocean Wealth is “A Thriving Maritime Economy”, which focuses on the market opportunities to achieve economic recovery with socially inclusive and sustainable growth.

This research strategy considers seven broad themes under this heading, namely:

Bioresources; Advanced Technologies; Subsea Resources; Renewable Energy; Tourism & Leisure; Transport & Logistics; and Security & Surveillance. The field of Bioresources includes finfish aquaculture, shellfish aquaculture, algal cultivation, wild fisheries, seaweeds and the processing of marine biomass for both food and other use. While there is a range of distinct research disciplines and industry sectors involved in the Bioresources field, the policy and societal drivers are common.

Each of these seven research themes is capable of driving economic activity from Ireland’s ocean resources as identified in each of the interventions identified in the report of the Development Task Force, namely:

- *Strengthening* existing marine industries such as fisheries and aquaculture.

- *Developing* economic activity from as yet untapped resources such as ocean energy.

- *Marinising* areas of economic strength which Ireland possesses through extending existing sectors into marine markets in areas such as transport and security & surveillance.

Research in this field also crosses over into research supporting policy formulation, e.g. in terms of social acceptability and environmental impact of proposed developments and economic activity.



# Bioresources – General

## Overview

Marine Bioresources comprises species that exist naturally in the marine environment and also include marine species that can be cultured in the sea or facilities on land. Ireland's marine bioresources comprises many forms, including e.g., whole fish, aquaculture products, macro-algae (seaweed) – both wild and cultured, micro-algae, marine invertebrates and marine micro-organisms. The majority of Ireland's marine bioresources are used as food products and food ingredients resulting in a range of research and monitoring associated with the identification of health benefits, safe food and safeguarding the environment. Bioresources from the marine environment are also sources of biological, genetic and chemical diversity as the basis for novel compounds offering a wide range of applications, across many industry sectors.

Ireland's marine territories offer a natural competitive advantage because of their productive ecosystems. Maximising the opportunity this presents requires ongoing research to support solving the sustainability and efficiency issues of existing harvesting activity, while adding value to both harvested and cultured marine bioresources.

Ireland has a significant interdisciplinary research opportunity through its other food production fields, to ensure Ireland can benefit from its marine bioresources in support of environmental, economic and societal sustainability.

## Context

At the core of marine bioresources related policy is the role that these resources have in contributing to the growth of Ireland's largest indigenous industry sector – food production and processing – whilst also offering considerable scope to contribute to growth in other emerging areas of Ireland's economy.

**Food Harvest 2020** and more recently, **FoodWise2025** each point to growth opportunities for Ireland's marine bioresources sector in food – primarily as a source of food and food ingredients – but also including other areas.

Sector driven research plans make research connections between the marine and those industries that are unconnected with the marine. The

**National Strategic Plan for Sustainable Aquaculture Development** strives for a *“more competitive, technically efficient and innovative aquaculture sector”* through the application of knowledge, innovation and technology. The strategy contains specific research actions to achieve this goal, as well as actions aimed at ensuring sustainability.

The wild fisheries sector maintains good industry, policy and researcher performer coordination in the form of the **Irish Fisheries Science Research Partnership** and the **National Inshore Fisheries Forum**, which identifies on an ongoing basis topics for applied research. At an international level, there are similar levels of coordination provided by **International and Regional Fisheries Management Organisations**.

The **European Maritime and Fisheries Fund (EMFF) – Operational Programme for Ireland 2014-2020** aims at achieving key national development priorities along with the EU's "Europe 2020" objectives. The Operational Programme (OP) supports the general reform of the EU's **Common Fisheries Policy (CFP)** and the development of its **Integrated Maritime Policy (IMP)** in Ireland. The CFP aims to ensure that fishing and aquaculture are environmentally, economically, and socially sustainable and that they provide a source for healthy food for EU citizens. The EU's **Blue Growth** strategy is to the fore in identifying actions and opportunity areas related to marine bioresources, including aquaculture, and the use of biotechnology to unlock high-value compounds from marine bioresources for use by health, cosmetic, industrial bio-materials, food, feed and chemical industries. Blue Growth, the CFP and the EMFF Operational Programme each stress the importance of safeguarding biodiversity and protecting the marine environment in capturing or cultivating marine bioresources.

Research areas included in the **EU Horizon 2020** challenges provide insights to growth opportunities for the marine bioresources sector, which are common with national goals. Particularly relevant in an Irish context are the challenges that relate to sustainable primary production, harvesting and processing systems for food, and other bio-based products. This requires increased understanding of the impact of climate change and other environmental changes on the marine environment. Such understanding will provide opportunities for Ireland with regard

to food and feed security and safety, improved health and well-being, and the establishment of new markets for bio-based products.

Because of the export orientated nature of Ireland's seafood sector, Ireland has specific research interests in both food safety and fish disease management and prevention. These interests are in common with broader European Union interests reflected in the Sustainable Food Security aspects of Horizon 2020 which are likely to continue into future EU research framework programmes.

These themes and associated areas of focus are described in more detail in the following individual sub-themes.



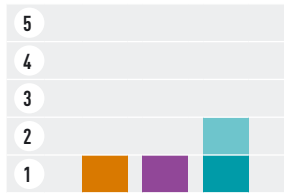
# Bioresources – Aquaculture & Biomass Production

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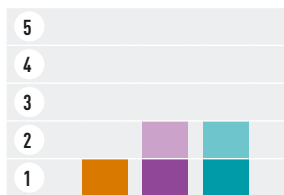
## Overview

Aquaculture has a key role as a sustainable source of seafood and other marine-based products. The focus of Ireland's aquaculture activity has traditionally been the production of finfish and shellfish for food use. This continues to be an area offering significant growth opportunities, coupled with increased demand for the sustainable production of animal protein. To take advantage of the increased demand requires increases in the output from aquaculture, with an emphasis on high-value species. Research to support culturing marine species for food will continue and be expanded to include culturing species for use in areas other than food. The production of biomass by culturing macro – and micro-algae and other micro-organisms provides an additional source of raw materials for use in a variety of market areas.

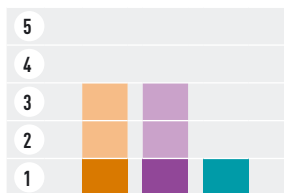
### Finfish Aquaculture (Ad-Hoc)



### Shellfish Aquaculture (Ad-Hoc)



### Algal Cultivation (Ad-Hoc)



■ Capacity  
■ Infrastructure  
■ Networks

## Research Capabilities – Maturity Assessment

Ireland's aquaculture activity includes finfish, shellfish and algae (macro – and micro-algae) production. Research maturity in these areas is assessed to be **“Ad-hoc”**. Whilst common competencies are required in developing products from marine biomass, the scientific research capabilities required to maximise the yields from cultivated fish, shellfish and algal resources differ. Despite this, a broadly common maturity profile exists across each aquaculture area reflecting the need to expand capacity in what are priority research areas for the bio economy. Ongoing research is mostly led by institutional based Principal Investigators funded from national and international sources but with little obvious collaboration nationally. With the exception of algae, undergraduates have little or no exposure to aquaculture. Because of the regulatory requirements associated with aquaculture production, from an environmental, food safety and animal welfare perspective, there is significant capacity in the state sector in terms of monitoring and associated research.

## Research Topics

The National Strategic Plan for Sustainable Aquaculture Development highlights a number of specific research topics. In general terms these relate to: breeding, stock and strain selection, disease diagnosis and stock health, feed supply, production methods and production systems including multi-trophic production and also land-based systems.

In addition to these topics, there is significant opportunity and need for research topics that span between this and other research themes. Specifically, within the general marine Bioresources theme, there is justification for building greater research links between Aquaculture and Biomass Production and the expertise in High Value Products. Similarly, the application of expertise from the Ocean Observation, Climate Change and Biodiversity,

Ecosystems & Food-webs themes is required. The dynamics of the natural environment, and how these impact on breeding, yields and survival of stock continue to be an area requiring focus, especially in ensuring that there is an adequate understanding of aquaculture activity in the context of the Irish environment and the potential threats to production and food safety from naturally occurring environmental events and anthropogenic sources.

Improved understanding of the health status and welfare of cultured species at all stages in their life cycle is required to minimise disease and control parasites through early warning systems and improved diagnosis. Research is also required to identify measures to minimise the use of treatments and mitigate against tolerance/resistance to treatments. Novel approaches to enhance biosecurity and bio-containment (including escapes of cultivated species) are also required.

The reliance on traditional fish-meal based sources of feed for finfish aquaculture is not sustainable at current levels. Further identification and assessment of alternative, sustainable sources of protein (including those from wild sources) are required to support the expansion of fed-fish activity and ensure balanced nutrition throughout the production cycle. Similarly, increased knowledge about the interaction between genetics and nutrition will allow improved feed efficiency. Existing practices of in-feed medication, particularly antibiotics, should be examined from the perspective of their contribution to improved health and possible risk to the consumer.

Supporting the anticipated growth in global demand for cultured biomass for food, non-food use, and as new sources of feed will require the development of sustainable and competitive production systems and culturing regimes for fish and algae. Such developments require improvements to fish welfare and health, and a focus on minimising of biosecurity risks from escapes and pathogens. In the case of

algae, the challenges associated with breeding, cultivation and health at all stages of the life-cycle of important commercial species should be addressed. In this context there is a need to better understand the economic and environmental impact of alternative production systems for aquaculture; particularly regarding the large-scale culturing of algae and the scope that exists to introduce integrated multi-trophic production systems and where such aquaculture activities might be optimally located.

### Focus of Funding

The analysis of research maturity for the aquaculture and biomass production sub-theme identified scope to support improvements in research capabilities. Interventions to address the differences in human capacity, infrastructures, and networks and relationships that exist between shellfish, finfish and algal cultivation subthemes are needed to maximise the knowledge base available to Ireland's aquaculture industry.

Initial focus is required to create and strengthen research capacity, providing not only resources to engage in research, but also to facilitate and expand collaboration between Ireland's research performers and encourage more multi-disciplinary research.

Investments to provide new infrastructure, and to upgrade existing research infrastructures, are also required.

With the global demand for cultured marine products, the funding challenge is to enhance research capabilities by at least one level from the present level of "Ad-hoc" across all dimensions of aquaculture and biomass production research.



# Bioresources – Wild Resources

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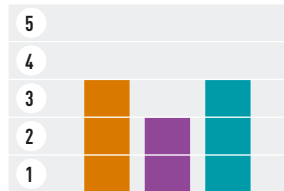
## Overview

Research related to the capture of species from wild resources under this heading includes all “wild” resources – fish, algae and other invertebrates harvested for food or other uses.

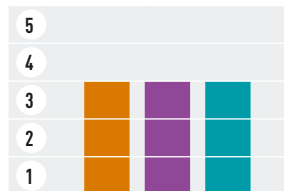
The wild capture of fish and shellfish from waters around Ireland is the largest source of marine biomass with close to 290,000 tonnes landed in Ireland during 2014. The wild fisheries sector is managed in accordance with EC regulations under the Common Fisheries Policy (CFP) and production is limited by the imposition of quotas, with most of the landings used as human food. There are a significant number of “non-quota” species that represent an important portion of the marine ecosystem whose productivity remains poorly understood. These include bioresources within the national territorial limits for fisheries, which are managed under national regulations.

The majority of the 40,000 tonnes of seaweed reported as harvested in Ireland is from wild sources and is dominated by the harvest of one species *Ascophyllum nodosum* (approximately 25,000 tonnes) that is used in the production of alginates and other polysaccharides. Other uses for wild harvested seaweed include animal feeds and animal health, horticulture (fertilizer), cosmetics, food and food ingredients.

### Wild Fisheries (Established)



### Seaweeds (Established)



■ Capacity  
■ Infrastructure  
■ Networks

## Research Capabilities – Maturity Assessment

The Research maturity assessments for both fisheries and seaweeds have been set at an “Established” level of maturity. Research capabilities in fisheries and seaweeds are based around a small number of Principal Investigators in three institutions and the state sector with internationally renowned experts in their areas. Undergraduate teaching programmes in Marine Sciences include modules in phycology, and marine biology, including fisheries. There is, however, an absence of postgraduate training programmes particularly in quantitative natural resource assessment. Whilst there is no large-scale harvesting of species other than fish, shellfish and seaweeds, there is an increased interest in other marine organisms, such as bacteria, sponges, jellyfish, sea squirts, sea cucumbers, starfish and micro-algae, as sources of novel compounds. There is a continued need for research and data to ensure the sustainable management of these wild resources.

### Research Topics

The continued sustainable capture and use of wild resources requires a research focus on understanding and managing that resource in an increasingly dynamic and changing environment and evolving policy instruments such as the Common Fisheries Policy (CFP) and the Marine Strategy Framework Directive (MSFD). There are an expanding number of disciplines that are being brought to bear upon this theme. In particular, the move from focused fisheries management to ecosystem based fisheries management is essential. This requires applied research on the direct and indirect impact of bycatch, resource competition and policy initiatives such as the landing obligation. This is further highlighted under the Biodiversity, Ecosystems & Food-webs theme.

Improved understanding of the impact of warming oceans coupled with changes to ocean acidity is needed to inform the future planning of assessment and monitoring regimes. Further, a greater understanding of the ecosystem is required. This includes the development of a more complete picture of previously uncaptured species, including non-quota and mesopelagic species.

As demand for algal biomass increases, research conducted at the level of individual species to assess their distribution and quantify the available biomass to support the definition and introduction of sustainable harvesting regimes for species of commercial interest is required. This research is closely linked to and complementary to the use of algae as the basis of value-added products and should include consideration of environmental factors on the growth and composition of wild species.

Best practice investigations to inform future licensing regulations for seaweed harvesting, which are linked to sustainable harvesting regimes for species of commercial interest are warranted to preserve and enable the sustainable use of such stocks.

In line with the research topics outlined above, research projects should provide information which can be used to facilitate resource management. All wild marine harvesting has to be informed by accurate assessments and feedback from monitoring systems designed to provide knowledge about stocks, the sustainability of harvesting, and cumulative and in-combination impacts. The development of prediction and modelling tools that support an integrated approach in decision making relating to the exploitation of all wild species should be supported.

### Focus of Funding

Given the “Established” nature of wild marine bioresources research in Ireland, as identified by the research maturity analysis, funding under this theme should be focused on widening the inter-disciplinary nature of projects and ensuring access to, and the provision of, essential infrastructures. The support for projects that aim to improve our understanding and management of all wild stocks, will add human capacity to areas where Principal Investigators have demonstrated considerable success in securing research funds, including leading international projects. National funds should also be directed towards areas where projects are informed by and deliver a mix of both policy and industry advice. Such actions will build on what is a solid foundation, enabling further capacity, infrastructure and collaborations to continue to provide knowledge that enables the maximum sustainable use of an asset of increasing strategic importance and position Ireland’s researchers to expand their leadership role in international projects.



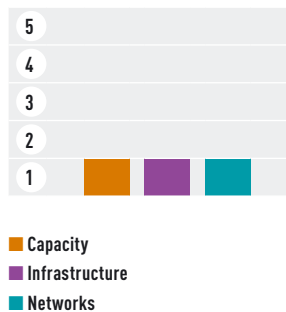


# Bioresources – Processing for Food and Other Use

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## Overview

Both wild harvested and cultured marine bioresources, sometimes described as marine biomass, are processed as a step in a number of value-chains. This processing differs from the extraction of products from biomass as input material for high value products as explored further in the next sub-theme, High Value Products. In the case of fish used for food, the majority of processing is primary in nature and typically involves filleting, preservation and packaging. Processing of algal resources, or the co-products of fish processing, typically involves a transformation of the raw materials using thermal, chemical, enzymatic or other processing technique, and subsequent biorefining. The potential exists to shorten the supply chain by a closer integration of culturing processes with transformation and biorefining. This supports expanding the use of cultured marine biomass for more than just food use. Other than as a research topic there is limited processing of the range of wild species used in discovery related activity.



### Research Capabilities – Maturity Assessment

Ireland's fish processing sector relies greatly on processing innovations developed by suppliers; while product development activities are supported by various semi-state agencies. The increasing importance of non-traditional sources of marine biomass – principally macro-algae and micro-algae, although 'industrial' finfish species may also play a role – provides Ireland's research community with opportunities to develop a biorefining approach to transform raw materials into specific compounds. In doing so, new opportunities for collaboration involving biologists and engineering expertise are being created in what is generally seen as an emerging area of research. Research maturity in this area is assessed as **"Ad-hoc"**.

### Research Topics

This is a theme with highly applied research requirements, as reflected by the requirement in the National Strategic Plan for Sustainable Aquaculture for applied research and collaborations between industry, scientific and development bodies. Research topics in this theme need to support development programmes, such as the European Maritime and Fisheries Fund Operational Programme 2014-2020 and the National Strategic Plan for Sustainable Aquaculture Development, in the exploration of technical or economic feasibility of innovative products or processes. Such topics include actions that lead to innovations in the supply chain, promoting sustainable processing technologies and new methods of cultivating and refining marine biomass.

As noted above, Ireland's established processing sector typically relies on innovations developed by suppliers of food processing equipment, and this is reflected in an "Ad-hoc" level of research maturity across the theme. As a consequence, future research topics will require funding instruments that can bring established research expertise from other sectors into the marine domain; for example in the areas of storage, transport, food safety and traceability.

Research infrastructure in this theme needs to support the goal of expanding the use of marine bioresources as the source of ingredients in food, health, cosmetic, chemical and biomaterial products. Such infrastructure needs to focus on the provision of test and demonstration facilities that allow the development and test of processes that ensure continuity of supply, meet exacting safety and product quality requirements and offer processors flexible, adaptive production systems.

With regard to developing new methods of refining marine biomass, significant scope exists to adapt technologies such as synthetic biology and other technologies to support the production of new products. Integrated, multi-stream biorefining can enhance sustainability and bring about improvements in production output and overall competitiveness, as a result of closer interaction between production and processing steps, including refining multiple species or sources of biomass into specific fractions.

### Focus of Funding

There is a requirement for increased access to infrastructure to support research in what is an increasingly complex technology enabled area. This would increase participation in collaborations. A key requirement is the provision of funds designed to build capacity around Principal Investigators, leading to the generation of critical research mass.

In a thematic area such as this, where research is almost always multi-disciplinary, and relies on contributions from a range of industry and academic specialists, research funds need to be directed towards building capacity that encourage participation in collaborative projects nationally and which also support access to research infrastructures. The impact of such funding would be to contribute to enhancing the research maturity level at a time when the demand and availability of biomass is set to increase.

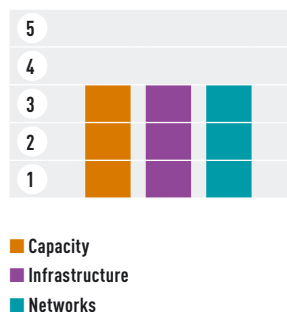


# Bioresources – High Value Products

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## Overview

High Value Products from bioresources refers both to those products that can be extracted from biomass and used as input material for other products and those other products themselves. In addition to highlighting the need for food production systems to be more sustainable, European policy on the bioeconomy also identifies marine bioresources as a source of novel processes and products that can be unlocked by marine biotechnology. Typically, those extracted materials represent a small volume of the original biomass material. Examples include food ingredients derived from fish and macro-algae providing food products with enhanced stability, flavours, colour and used as edible films and food coatings. More sophisticated products include extracts with important techno-functional properties that are used in functional foods, food supplements and nutraceuticals. Lipids, proteins, polysaccharides, pigments, fibre, and minerals can be obtained from marine sources in order to provide nutritional and other benefits to humans and animals. There are also new pharmaceuticals derived from marine organisms to treat pain, some cancers and to reduce levels of triglycerides that are associated with atherosclerosis and a noticeable rise in interest in the use of marine derived natural products in health and related areas. It is not only food and health areas that offer opportunities for marine derived compounds/natural products. Marine organisms are known sources of enzymes, biomaterials, industrial chemicals, cosmetics, and personal care products and with known applications in the horticulture and feed sector.



## Research Capabilities – Maturity Assessment

National research funds have created a critical mass and stimulated collaborative research in a range of related areas supportive of the exploration and discovery of novel compounds from marine bioresources by deploying marine biotechnologies. A solid foundation of internationally recognised research involving a cohesive group of Principal Investigators from Irish research institutions exists to generate knowledge that supports the creation of high-value marine origin products. The research maturity is assessed as **“Established”**.

## Research Topics

Required research topics under this theme reflect the fact that materials derived from marine resources can support several value chains. The common root of these value chains relates to bioprospecting and discovery, a topic area that relies on collaborative research and technologies developed outside the marine biological area and marine biotechnology. It is also an area that is diverse in terms of the required collaborations with the marine sciences – novel materials can be sourced from both unexplored marine environments or from the by-products of established biomass processing.

Once materials have been identified, isolated and either cultured or synthesised, there are a range of application areas that provide possible research topic areas. These include food, feed and food ingredients, health and pharmaceutical applications, as well as a scope in materials science and engineering.

## Focus of Funding

The analysis identifies the High Value Products research as **“Established”** and hence well positioned to continue to make an impact in maximising the inherent value of marine biological resources for use in new value-added products. Success in attracting both national and international funds supported the creation

of research capacity, research infrastructure and enabled participation in different research networks. The thematic area is well positioned to benefit from funding initiatives designed to build on current achievements of existing Principal Investigators and collaborators. Such funding, when directed towards projects that continue to enhance research capacity, also needs to support the acquisition of new essential infrastructure, since the combined effects provides a foundation for collaborative research involving national and international research centres and industry.

Outside of the marine domain, the bioeconomy is a field of increasing importance at an international level. Given the defined nature of the research community in the field, funding should focus on ensuring that this community is able to collaborate both nationally and internationally. In particular, integration of marine bioresource expertise with centres that support screening for novel compounds and bioactive materials is fundamental. New tools and methodologies are required in the field to enhance the biodiscovery process, including: data mining techniques, remote sensing, and metagenomics.

Similarly, there should be a focus on supporting collaborations with potential application areas in the food, animal feed, pharmaceutical and health product sectors.

In addition to this ongoing need to promote inter-disciplinary research, there is also a need to nurture and sustain a core cohort of marine biodiscovery researchers and value-added application research capacity. In particular, this capacity must be supported by infrastructure that can support the pooling of knowledge (e.g. a repository of samples supported by appropriate intellectual property protection) and access to specialised marine equipment including culturing facilities and ocean going equipment.

# Advanced Technologies

## Overview

Ireland's existing capabilities in ICT and engineering provide a solid foundation for marine technology markets in areas such as sensors, platforms, advanced materials, subsea communications, robotics, computer vision, simulation, observation, forecasting, informatics and modelling. Clusters of activity and world-class infrastructure have emerged through existing investments. This foundation provides the basis to establish Ireland as a centre of excellence in the development, test, demonstration, commercialisation and delivery to market of the next generation of innovative marine technologies and technology based services. Expertise across the ICT research and enterprise sector is also recognised as a key enabler for the achievement of developmental and management objectives across the entire marine sector.

## Context

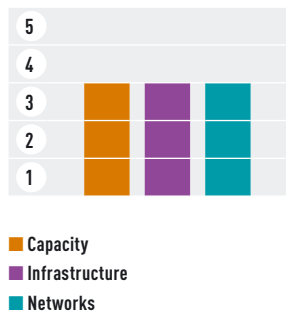
Research in ICT continues to be a priority area and it is one of the six broad enterprise themes in **Innovation 2020** covering a number of the areas from the **National Research Prioritisation Exercise**.

**Harnessing Our Ocean Wealth** and the subsequent **Development Task Force** report outlined a strategy to "marinise" our existing ICT sector to leverage additional opportunities in marine-related markets. This is directly aligned with the recommendations in **Enterprise 2025** in relation to realising untapped potential of sectors that present opportunity for growth.

From a European policy context, the EU's **Blue Growth** strategy recognises the role of technology in creating an opportunity to harness the untapped potential of Europe's oceans.

**Marine Knowledge 2020** presents a strategy on improving marine knowledge as a "key element to achieve smart growth in the European Union in line with the Europe 2020 Strategy".

The **EU Strategy for the Atlantic**, and the associated **Atlantic Action Plan**, highlights priority areas for research and investment in marine technology to drive blue growth in the Atlantic area.



### Research Capabilities – Maturity Assessment

The research capability of the Advanced Marine Technology theme is assessed at **“Established”**. This reflects recent Irish success in applying a range of skills to the marine area, coupled with a number of now well established research centres with a water/marine focus.

### Research Topics

Given existing capacities and investments across ICT, engineering and marine, research topics should focus on the application of a broad range of topics to the marine domain.

These include, advanced sensors, in-situ and airborne and space-borne monitoring platforms, data acquisition and communications, data processing, cataloguing and management, informatics, visualisation, virtual/augmented reality, forecasting and prediction, robotics and autonomous systems, and materials and systems that can withstand harsh environments, including concrete and other engineered structures.

This requires expertise across a number of areas which include: big data, machine learning, artificial intelligence, computer vision, remote sensing, streaming data, high performance computing, cloud computing, nanotechnology, materials science, photonics, wireless networks, acoustics, microelectronics, analytical chemistry, modelling and simulation. Relevant expertise in engineering and energy capture will also play a critical role.

### Focus of Funding

In order to transition from an “Established” to a “Collaborative” maturity level for research in advanced marine technologies, the key focus for funding includes:

- Supporting and incentivising collaborative research between ICT and marine-focused research centres, including effective and sustainable inter-institutional research collaborations.
- Establishing a research programme of scale in Ireland in the Marine ICT field, which will attract international interest from researchers and industry to utilise Ireland’s research infrastructures for joint marine and ICT research.
- Centre the research programme on a world-leading research infrastructure that can provide Ireland with a competitive advantage to secure further international investment, for example in maritime surveillance or ocean observation systems.
- Developing active partnerships and collaborations with industry.



# Subsea Resources

## Overview

The development of Ireland's indigenous subsea hydrocarbon and mineral resources has the potential to deliver enhanced security of supply, import substitution, fiscal return, national and local economic development and technology learning. The development of subsea natural resources is supported by Irish research in a diverse range of disciplines.

Hydrocarbons will remain a significant element of Ireland's energy supply in the evolution to a low carbon energy system. In the short to medium-term, the mix of non-renewables will shift away from more carbon-intensive fuels, like peat and coal, to lower-carbon fuels like natural gas. In the longer-term, fossil fuels will be largely replaced by renewable energy sources. Successful exploration off the Atlantic coasts of Africa and Canada has stimulated new interest in the potential of the Irish Atlantic Margin, with new data, analysis and targets.

There are also offshore marine aggregate resources that may be economic to develop in the future. The potential for deep sea mining offshore Ireland is currently unknown but is thought to be limited.

## Context

The **White Paper on Ireland's Energy Policy** ("Ireland's Transition to a Low Carbon Energy Future 2015-2030") identifies security of supply as an important component of energy research.

**Innovation 2020** commits to implement research related actions in the Energy White Paper.

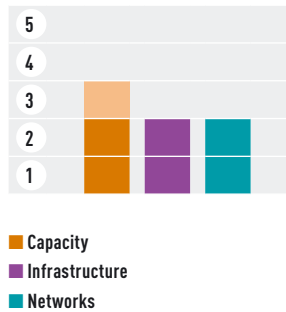
The **International Ocean Discovery Program's** (IODP) new science plan (2013-2023) addresses fundamental questions about Earth's climate, deep life, geodynamics, and geohazards,

facilitating a long-term, global perspective on some of today's most pressing environmental issues.

A key action of **Harnessing our Ocean Wealth** is to continue to implement research supporting increased hydrocarbon prospectivity through government-industry collaboration. The subsequent report of the **Development Task Force** recommended continued investment in baseline data collection, and related infrastructure and knowledge development, to ensure

that Ireland's natural subsea resources are managed in compliance with European and Irish environmental law whilst supporting the exploration and discovery of oil and gas in Irish waters.

The **European Marine Board Policy Brief No.2** identifies knowledge gaps in marine mining and oil and gas, in resource evaluation of ore and gas hydrates, and baseline knowledge to support development of appropriate environmental impact assessments and effective regulation.



## Research Capabilities – Maturity Assessment

The subsea resources research field has a **“Defined”** capability overall. “Established” maturity in the human capacity dimension reflects a significant history of research associated with the field. This has resulted in well-developed industry connections. Recently, the establishment of a number of relevant SFI research centres (i.e. iCRAG, MaREI) has further cemented this capability and is serving to de-risk exploration. Research capacity is high with respect to human capacity and data infrastructure (e.g. seismic and technical data available through programmes such as INFOMAR and data via the State aimed at promoting petroleum exploration). Scope also exists for further inter-institutional, industry and international collaboration including the technology exchange between oil and gas exploration and production activities and offshore renewable energy.

## Research Topics

Existing research topics are targeted at unlocking Ireland’s subsea resources by de-risking exploration. Priority topics to achieve this include:

- Improved understanding and models of the geology and related processes;
- Environmental baseline acquisition studies to support sustainable development of subsea resources;
- Improved knowledge of the environmental factors controlling the ocean, seafloor and sub-seafloor;
- Innovative techniques for predicting the location and nature of resources; and
- Improved methods for optimising the efficient production of resources.

Research priorities identified by the global oil and gas industry are also applicable in the Irish context. These include inspection technologies, the use of Big Data technologies for subsurface imaging, asset integrity, logistics, regulatory consent monitoring and production efficiency, and automation and robotics for cost efficiency and improved health, safety and the work environment.

Existing cross-cutting research capabilities in Ireland could contribute to this global research agenda; for example, many of the topics are linked to the advanced technologies and engineering research themes.

## Focus of Funding

The success of recent investments (e.g. SFI and PIP ISPSG, ObSERVE) will play a key role in delivering ambitions for the increased research and innovation to support the sustainable development of subsea resources. Ireland’s geoscience research base has a track record of industry engagement.

A focus on improving and increasing access to research infrastructure such as data, through funded open access programmes, and expanding the high-end computing capacity in Ireland, combined with postgraduate funding, will ensure future capacity building and sustain maturity levels.

Funding to support “Networks & Relationships” should be focused on promoting the opportunities generated by Irish research to marine international networks dealing with sub-seafloor themes.

# Renewable Energy

## Overview

Ireland has natural resources of offshore wind, tidal and wave energy that can be harnessed as clean, sustainable and secure energy, meeting Europe's energy and climate change goals. Beyond energy creation, greater enterprise and FDI opportunities exist in the knowledge-based, scientific and engineering sectors needed to harness these resources.

## Context

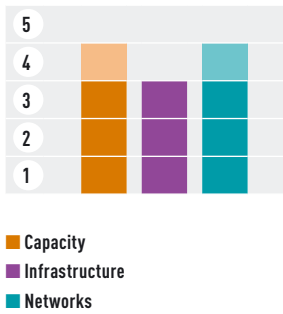
Ireland's enterprise policy **Enterprise 2025** identifies "Marine" and "Green technologies" as sectors where untapped potential can be realised to contribute to job creation and sustainable economic growth targets.

**Harnessing Our Ocean Wealth** and the strategic framework outlined in the report of the **Development Task Force** includes "Energy from the Ocean", reflecting Ireland's marine renewable energy potential. The European Union has also identified Ocean Energy as a sector that has high potential for sustainable jobs and growth in its **Blue Growth** strategy.

The **Strategy for Renewable Energy: 2012-2020** identified the opportunity for Ireland to become a world leader in the testing and development of next generation offshore renewable energy equipment. The **National Research Prioritisation Exercise** has a priority area on "Marine Renewable Energy".

The **Offshore Renewable Energy Development Plan (OREDPA)** sets out policy to take full account of the energy, economic development and environmental issues associated with the exploitation of our national offshore wind and ocean resources. This is supported in the Energy White Paper "**Ireland's Transition to a Low Carbon Energy Future 2015-2030**" and obligations to meet EU commitments to lower greenhouse gas emissions.

The recently published **Strategic Research Agenda for Ocean Energy**, produced by the European Technology and Innovation Platform for Ocean Energy, provides a detailed suite of research and innovation measures necessary to accelerate the development of this emerging industry.



## Research Capabilities – Maturity Assessment

The renewable energy field of research has been assessed as **“Established”** moving towards “Collaborative”. There is strong human capacity with good networks and relationships. There are some collaborative activities in the infrastructure dimension, e.g. postgraduate and postdoctoral training. The extent to which the capacity is applied to the marine field, as distinct from the wider renewable energy field, is an issue that requires an increase in dedicated focus on marine elements.

## Research Topics

The European Strategic Research Agenda has identified a need for testing and modelling across the TRL (Technology Readiness Level) range. This includes a focus on cost reduction to ensure marine renewable energy technologies can become competitive among the suite of low carbon energy technologies that will form the backbone of the energy system.

Support for Irish research projects in these areas will enable opportunities to compete for Horizon 2020 funding.

A specific focus of research should recognise that there are fundamental similarities between subsea resources and offshore renewable energy in terms of marinisation, OPEX costs and installation in dynamic environments. Similarly, ocean energy research infrastructures in Cork (Lir Centre), Galway (SmartBay) and Mayo (AMETS) can have application beyond ocean energy research.

## Focus of Funding

To enable maturity in research capacity across the three dimensions, the following summarises the direction of the funding required:

- Focussing funding on a research project of significant scale, aimed at providing a stable research leadership in Ireland.
- A suitably designed Small Business Innovation Research (SBIR) initiative, leveraging the LIR and Galway Bay facilities, would attract inward investment and potentially position Ireland as a world-leading hub for the deployment of marine renewable energy technologies and services. This could take the form of a Pre-Commercial Technology Fund (PCTF) to close the ‘funding gap’ for device and sub-system developers at TRL3+ and to complement the current Prototype Development Fund.
- Attracting demonstration projects could be achieved with a flexible approach to capital grants and feed-in tariffs that can avail of opportunities in this area as they emerge.
- A review of the implementation of the IP protocols, providing access to finance suitable for new enterprises and supporting innovation in established businesses in the core marine renewables sectors is required to ensure sufficient industry strength to lead the research agenda in research teams and centres such as MaREI.

# Tourism & Leisure

## Overview

Irish Tourism is in a period of unprecedented growth. With 70% of tourists concentrated in coastal areas representing 30% of the country, development of tourism in coastal and marine areas is essential. International consumer research indicates that a growing number of consumers seek unique and authentic experiences such as the Wild Atlantic Way proposition. This harnesses the marine asset and maritime heritage as a key point of differentiation, providing an indication of the scope for future development and research.

## Context

**Harnessing Our Ocean Wealth** sets revenue targets for 2020 of €1,500 million arising from tourism in marine and coastal areas. This makes this sector the second most important contributor to the plan. The subsequent report of the **Development Task Force** identified tourism in coastal and marine areas as a cornerstone of its coastal and marine business theme.

**People, Place And Policy – Growing Tourism To 2025**, published by the Department of Transport, Tourism and Sport notes the links between a healthy marine environment and tourism offerings.

**The Tourism Action plan 2016 – 2018** includes a focus on engagement by tourism agencies with other state agencies and a focus on Ireland as a food destination (including seafood) in its actions.

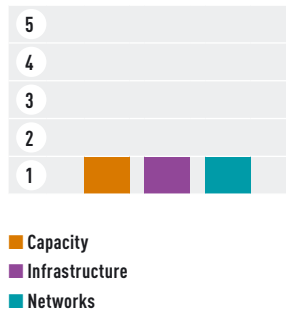
The **Wild Atlantic Way Operational programme** contains significant synergies with the Development Task Force and Harnessing Our Ocean Wealth, while the publication and subsequent implementation of **Fáilte Ireland's Investment Strategy** is key to the continued support of tourism (and leisure) related products that rely on both Ireland's unique coastal and marine assets. The focus of the investment continues to provide support in many coastal areas, particularly along the route of the Wild Atlantic Way.

The Commission for the Economic Development of Rural Areas (CEDRA) report, **Energising Ireland's Rural Economy**, and the subsequent **Action Plan for Rural Ireland** (2017) has a number of relevant recommendations for the development of tourism in rural (and by implication, coastal) areas.

The Plan also identifies a number of specific actions related to angling and the development of 'Blue Ways'.

At a European level, the **EU Atlantic Action Plan** has a number of tourism related priorities. Of specific focus in 2017 is the area of nautical tourism.

There are a range of other regional and sectoral plans and initiatives prepared by organisations such as the Commissioners for Irish Lights, BIM through their Fisheries Local Action Groups and a number of the Harbour Companies and County Councils. Inland Fisheries Ireland continue to focus investment and research in the area of angling, with sea and shore angling an important aspect of Ireland's tourism product.



### Research Capabilities – Maturity Assessment

The Tourism research theme is assessed to be **“Ad-hoc”**, but with considerable scope to progress to “Defined”, based on refocusing an active community of interest to the marine. Research is primarily focused on market and consumer research with strong communities of interest built up at a regional and local level. Research linked to environmental, social and economic impact assessments of specific programmes is often commissioned at a project/programme level.

### Research Topics

Research activity should focus on: innovation in delivering new visitor experiences, performance and destination development benchmarking, consumer research and trends, citizen/community engagement and awareness and a national maritime interpretation strategy. Research in this area should be closely aligned to the topics identified under the Marine Policy & Governance theme.

### Focus of Funding

Given the low maturity assessment, initial focus in this area should be to act as a catalyst to build partnerships and networks.

Consideration should be given to funding interventions at three levels – national, community and institutional:

- Engage with the proposed National Tourism Research Forum to align existing expertise and resources amongst the academic and agency community. This would act as a catalyst to focus on products linked to marine and coastal assets. Consideration should also be given to a Research Award.
- Address relevant issues, opportunities, and identified gaps through a Tourism Innovation scheme to support coastal community/academic partnership research and develop new visitor experiences harnessing marine resources and maritime heritage, technology and links with other marine disciplines.
- Build and encourage new research capacity through funding PhD positions. This will build the capability and capacity into the future to facilitate targeting EU funding applications. Such research will add to the national tourism and maritime development agenda.

# Transport & Logistics

## Overview

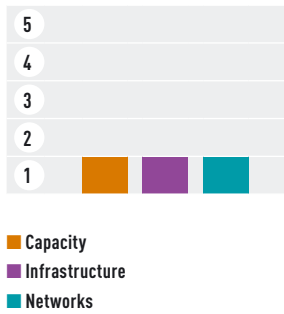
Maritime transport is a key component in international trade and supply chains. The maritime transport sector in Ireland has three main activity areas: Ports and Maritime Logistics, International Maritime Services, and Seafaring (which covers the training and certification of seagoing crew). There is a very low-level of functioning R&D capacity in the ports and maritime transport sector, which is a major weakness that needs to be addressed. The planned development of the International Shipping Services Centre (ISSC) to create a global centre of excellence has potential to attract investment in R&D. Ireland has strengths in the cross-cutting areas of ICT and clean, efficient energy for the maritime transport industry that could be developed.

## Context

Ireland's **National Ports Policy** is focused on facilitating a competitive and effective market for maritime transport services, and **Harnessing Our Ocean Wealth** identifies the role the maritime and ship leasing field plays in the competitiveness and connectivity of the economy.

The **Development Task Force** report identified growth opportunities for Ireland's maritime transport sector that are also areas included in the prioritisation that underpins **Innovation 2020**, for example, "*Data Analytics, Management, Security & Privacy*" that has applications for shipping services and "*Smart Grids and Smart Cities*" for intelligent ports.

The research capacity on these cross-cutting areas in Ireland provides an opportunity to participate in the Horizon 2020 Work Programme "**Smart, green and integrated transport**", which has specific maritime transport calls where economic, environmental and social sustainability, along with improved maritime safety, is the key challenge for waterborne transport.



### Research Capabilities – Maturity Assessment

An “Ad-hoc” assessment reflects that while there is transport and infrastructure research clusters in Ireland, this research is predominantly on land-based transport and relatively few research projects into maritime transport have been undertaken. Communities of interest do exist, but these are not reflected in significant research output or infrastructures.

### Research Topics

Research topics relevant to Ireland are largely driven by the EU research agenda for maritime transport. The strategic objectives for the European maritime transport system up to 2018 are focused on “*the adaptation of the entire seaborne transport system to the challenges of the 21st century*” that spans the areas of competitiveness underpinned by safe, secure and efficient shipping on clean oceans and seas.

### Focus of Funding

The review of research capability shows a requirement for such instruments addressing all three dimensions of the research maturity model – capacity, infrastructure and networks and relationships.

Support for cross-cutting research on maritime transport & logistics to establish capacity for direct transport related research is required. This could be improved by strengthening and adding maritime fields to existing research centres in transport and research centres in the cross-cutting areas of ICT and data analytics.

The need to stimulate industry collaboration in research through instruments such as a targeted Small Business Innovation Research (SBIR) programme could also enable the utilisation of existing infrastructures in ports as “test-beds” for new enabling technologies that contribute to national research priorities in ICT, data and renewable energy.

Exchange programmes that could attract leading maritime transport researchers to Ireland would assist addressing capacity in the short term and could be used as a stepping stone to building a more sustainable research capacity in this area.

Targeting the EU Commission’s roll out plans for Innovative Financing Tools is required. This could be achieved through a pilot scheme in Ireland that builds on the lessons learnt from the Netherland’s “Shipping Financing Tool” and expands similar tools into infrastructure, alternative fuels and inland shipping.



# Security & Surveillance

## Overview

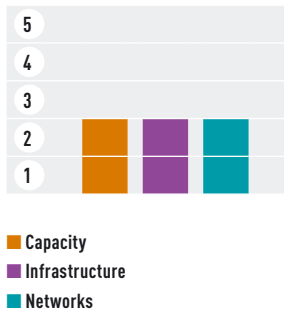
Ireland's unique location on the western periphery of Europe, and a gateway to the Atlantic, provides opportunities to develop and test smart maritime safety, security and surveillance products and services for an expanding global market. Capacity, networks and expertise in this domain are mostly cross-cutting in nature, with links in particular to the Advanced Technologies research theme. However, particular specialist expertise will need to be developed by leveraging existing domain knowledge and test beds available through the Irish Defence Forces, the Irish Coast Guard, the Marine Institute, the Commissioners of Irish Lights, and other similar organisations. Technologies developed in this area also have wider application, for example in the operation and maintenance of offshore facilities.

## Context

Maritime Safety, Security and Surveillance is one of the key enablers of **Harnessing Our Ocean Wealth**. The report of the **Development Task Force** proposed a demonstrator initiative under the thematic area of "Integrated Marine Capacity & Capability". Ireland's **White Paper on Defence** highlighted that many of the risks and threats listed in the EU Maritime Security Strategy are relevant to Ireland's maritime domain.

An objective of the European Union's **Maritime Security Strategy (EUMSS)** is to promote the development of innovative technologies that contribute to improved efficiency and effectiveness of operations and information sharing.

Integrated Maritime Surveillance is outlined as one of the essential components of the EU's **Blue Growth** strategy and a **Common Information Sharing Environment (CISE)** is being developed jointly by the European Commission and the EU/EEA Member States. Similarly, one of the priorities of the **EU Atlantic Action Plan** is to "Protect, secure and develop the potential of the Atlantic marine and coastal environment", with specific objectives on *improving maritime safety and exploring and protecting marine waters and coastal zones*.



### Research Capabilities – Maturity Assessment

Despite being a relatively newly defined area for marine-related research, the Security and Surveillance theme is at the **“Defined”** stage in terms of Human Capacity, Infrastructures and Networks & Relationships. This reflects the cross-cutting nature of the field which can take advantage of capabilities in related fields.

### Research Topics

Future investment should focus on the development and implementation of systems that provide real-time operating, surveillance and monitoring information on activity in the maritime domain, along with the delivery of cutting-edge technologies that can deliver this information from harsh and remote environments in a real-time manner.

### Focus of Funding

By further leveraging capacity outlined in the area of Advanced Technologies research theme, an increase in the maturity level associated with this theme can be achieved. Key to this will be creating opportunities for collaboration between research teams and industry with expertise relevant to this sector.

The development of existing facilities with direct water access, nearby port infrastructure and relevant expertise, along with other test beds and platforms being deployed for other sectors, could help to form part of a multi-platform offering that would include this sector. Purpose built platforms to support research in maritime security could help to attract interest from EU and international researchers as a stepping stone to creating a national research centre for the sector.

Full engagement of the relevant agencies in the objectives of the Defence Enterprise Initiative and further development of industry-oriented research collaborations will be necessary. Additionally, the development of a cross-institutional interdisciplinary research team that further builds on existing capacity, infrastructure and relationships with industry will help to advance the networks in this domain.

Capacity across the research and enterprise sector has been mapped across the general thematic area of security and a similar exercise with a more refined focus on the maritime domain may help to further facilitate collaborations. However, the ability to leverage capacity from other sectors will also be critical. The enterprise base is at a low but emerging. Incentivising research linkages with this emerging enterprise base could help create the platform for more industry funded research in the medium to long term.





# Healthy Marine Ecosystems

The second goal of Ireland's Integrated Marine Plan, *Harnessing Our Ocean Wealth*, is to protect, preserve and, where possible, restore Ireland's rich biological diversity and ecosystems. To do this, a deep understanding of the functioning of the ecosystems that are at work in our expansive maritime territory is required.

A significant area of research is the related areas of Biodiversity, Ecosystems & Food-Webs. This strategy treats these topics together, although they are often arrived at from the diverse perspectives of environmental protection and sustainable food production, as they have common knowledge fundamentals.

A highly visible, and in some cases invisible, sign of human impact on the marine environment is the topic of Pollution and Litter. Apart from the obvious legislative and societal need for preventing and reducing marine litter, there are potential economic drivers also. These include the potential impact of pollutants and microscopic particles on the food chain, and the implications for food safety including trade implications.

Our collective understanding of our planet's ocean processes is underdeveloped. Initiatives such as the joint Geological Survey of Ireland/Marine Institute INFOMAR programme has resulted in increased knowledge and understanding of our maritime territory. However, we have an underdeveloped understanding of the dynamics of the ocean within this claimed jurisdiction and also in the wider North Atlantic. Ocean observation and seabed mapping is a field where Ireland, despite having an

established research community, needs to move to a highly collaborative level. It is a foundation discipline for a range of marine sciences.

Of specific focus globally and nationally is the area of climate change, one of the great societal challenges of our time. Discussions of climate change require us to take account of the pivotal role our oceans play in regulating climate. Ocean acidification is impacting directly on ecosystems and food-webs; while changing ocean temperatures is driving changes in the atmospheric dynamics and impacting on our terrestrial environment in the shape of extreme weather events and changes in crop production.

This section of the strategy deals with these four topics: Biodiversity, Ecosystems & Food-Webs, Pollution and Litter, Climate Change, and Ocean Observation and Seabed Mapping. These topics are intrinsically linked to achieving a thriving maritime economy, and the need to deepen our engagement with the sea.



# Biodiversity, Ecosystems & Food-webs

## Overview

An understanding of Ireland's marine biodiversity and ecosystems function, through research and monitoring, is complex yet fundamental to economic growth and the sustainable use of marine resources. Achieving a shared understanding enables ecosystem goods and services derived from the marine resource to be sustainably managed into the future. It requires the development of robust indicators that can be monitored over time. Research in Ireland is driven largely by sectoral requirements, such as the ecosystems approach in fisheries management, and requirements from environmental legislation. Otherwise, research effort has mostly focused on small-scale primary research resulting in gaps in understanding and knowledge of marine biological diversity, ecosystem functioning and marine food-webs. Addressing these knowledge gaps requires the development of scientific, technical and institutional capacities to expand the scope of research in the field.

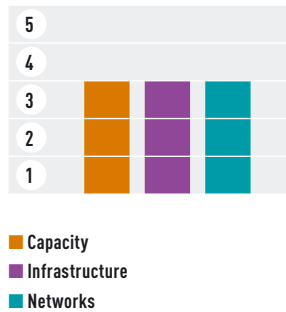
## Context

The overarching context for research in this field is driven by the ecosystem-based management approach to the marine environment that is enshrined in a number of international and national policies and legislation such as the EU's **Common Fisheries Policy**, **Water Framework Directive**, **Marine Strategy Framework Directive**, **Natura Directives**, the **OSPAR Convention** for the protection of the environment of the North-East Atlantic, the **Maritime Spatial Planning Directive**, and the **United Nations Sustainable Development Goal 14** – Conserve and sustainably use the oceans, seas and marine resources. The **United Nations Convention on Biological Diversity (CBD)** provides the

framework for the conservation and sustainable use of global biodiversity; while the **EU Biodiversity Strategy** provides the main policy framework to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020, as well providing protection from pollution by understanding ecosystem function.

Legislative drivers include the transposition into Irish law of the various Natura conservation directives (**Birds and Habitats Directives**), Regulation 1143/2014 on **Invasive Alien Species (IAS)** and the **Marine Strategy Framework Directive (MSFD)**.

At a National level **Actions for Biodiversity 2011-2016** and the **draft third National Biodiversity Action Plan 2017-2021** were developed with cognisance of the EU Biodiversity Strategy and the CBD strategic plan to provide a strategy for the restoration and conservation of Ireland's biodiversity. Research on biodiversity, ecosystems and food-webs can be used to underpin the development of effective management measures to protect and conserve biodiversity while promoting sustainable development. This includes the formation and on-going development of a network of marine protected areas for Ireland.



### Research Capabilities – Maturity Assessment

This theme is assessed as being **“Established”**. While there is good Principal Investigator led capacity relating to some aspects, gap areas exist reflecting the concentration of expertise in a few Higher Education Institutes and state bodies. Key infrastructure exists in the shape of national assets such as the Marine Institute run research vessels. However, access to the required field and laboratory based technology is lacking in many areas of research. Enhanced collaboration between the variety of funding agencies addressing research in key areas is required to move to the “Collaborative” level.

### Research Topics

A number of applied research topics are identified to support policy decisions that will be required in the coming years. These include: (1) the identification and conservation of areas of high biodiversity value; (2) the establishment of long-term study sites and a programme of research to be conducted within these sites; (3) the development of an early detection and rapid response warning system for the identification and detection of Invasive Alien Species (IAS) in the marine environment; and (4) research that supports the development of monitoring programmes and associated assessments. This would include identifying risks to the Good Environmental Status (GES) as defined under the MSFD.

Research under these topic areas will enhance our understanding of the dynamics and pressures on biodiversity, ecosystems and food-webs in the marine environment. Such research will provide the basis for a natural resource management framework to support future environmental protection mechanisms that enable sustainable development.

This research theme also affords significant opportunities to link research efforts with other themes including: Pollution and Litter, Bioresources, and Integrated Policy and Governance. Such cross-purpose research topics include: (a) assessing the impacts of new and novel technologies; (b) marine food web modelling and; (c) primary diet data analysis and research.



## Focus of Funding

Movement of this research theme from the “Established” to the “Collaborative” level requires action across all three dimensions of the Research Capability Maturity Model. Instruments that support development on more than one dimension should be prioritised, for instance the development of inter-institutional research groups that will both increase human capacity and enhance the networks that exist nationally and internationally.

In order to build and maintain a dynamic marine biodiversity research community in Ireland research must be driven both by public policy requirements and fundamental scientific understanding.

To efficiently use available resources, a funding mechanism is required to support research networks that examine marine biodiversity and ecosystem function, and enable human capacity building in basic and applied research. Competitive research calls for marine biodiversity on the themes identified, that support a range of policy areas, should form part of such a funding mechanism.

It is recommended that this future mechanism should facilitate:

- The creation of human capacity with the necessary skill sets and experience to engage in the next generation of marine biodiversity, marine food web and ecosystem research. These skill sets include expert level knowledge in mathematics, statistics and taxonomy.
- A national research group that would act as a catalyst and support network for satellite researchers to successfully compete for and win EU funds. This capacity to win EU resources would be vital to address the transient nature of the human capacity within this research theme.

In addition, it is recommended that funding is focused on research that supports the aggregation of assessments to harmonise monitoring, reporting, and assessment requirements across a range of policy drivers such as the MSFD, Maritime Spatial Planning, Water Framework Directive, Habitats and Birds Directives, OSPAR Commission and other transboundary requirements.



# Pollution and Litter

## Overview

Adverse or potentially adverse effects can occur when chemicals, particles, industrial, agricultural and residential waste, noise, litter and biological pollutants e.g., invasive non-indigenous species (NIS) gain entry into or spread in the marine environment. The vast majority (approximately 80%) of anthropogenic pressures on marine and coastal environments is caused as a result of land-based human activity. While in some instances, the knowledge, know-how and plans to protect, preserve and restore our rich biological diversity and ecosystems, for the most part, exist and are in place, there is also an acknowledgment that there are elements of the research where knowledge is poor and the research needs to be further developed and tested. Actions to halt and reduce marine pollution and litter at the source/pathway level prior to interaction with sinks and receptors are required. Research has a significant potential to combat marine pollution and litter through development of a deeper understanding of the sources, scale, nature, impact, location and transport processes of pollutants, and the development of innovative solutions to prevent, detect, quantify and treat pollutants.

## Context

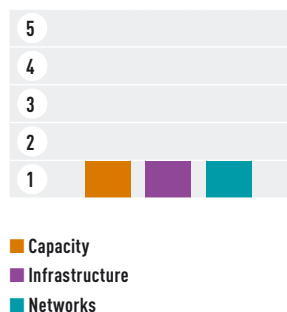
Development and industrialisation has resulted in an increase in the range and magnitude of pressures in Irish waters that have the potential to impact negatively on the quality of Ireland's tidal waters (EPA, 2016). Ireland's current approach to managing marine pollution and litter is largely driven by the **Marine Strategy Framework Directive (MSFD)** and the **OSPAR Convention** for the protection of the environment of the North-East Atlantic. The MSFD encapsulates several other important EU legislative instruments that include: the Water Framework Directive (WFD), the Urban Waste Water Treatment Directive, the Bathing Waters Directive, the Birds and Habitats Directives, the Environmental Quality

Standards Directive, and the Nitrates Directive. The MSFD also considers European policies such as the **Common Fisheries Policy** and international conventions including the **International Convention for the Prevention of Pollution from Ships (MARPOL)**.

Compliance with the various requirements under the above mentioned Directives can and will contribute towards the achievement of Good Environmental Status (GES) and wider objectives of the MSFD and vice versa. Of the eleven descriptors listed in the MSFD, six are relevant to this research theme. These are: *Descriptor 2* on Non-Indigenous Species (NIS), *Descriptor 5* on human-induced

eutrophication, *Descriptor 8* on the concentration of contaminants, *Descriptor 9* on contaminants in fish and other seafood for human consumption, *Descriptor 10* on the properties and quantities of marine litter, and *Descriptor 11* on the introduction of energy, including underwater noise.

The WFD also sets a goal of achieving Good Ecological Status and Good Chemical Status for all EU ground and surface waters (including intertidal, transitional and coastal waters out to one nautical mile), which directly complements the goal of GES under the MSFD.



### Research Capabilities – Maturity Assessment

The Marine Pollution and Litter theme is assessed as “Ad-hoc” though there is potential to move to the “defined” level. Despite a number of active research projects across several different research topics, the overall theme of marine pollution and litter is broad, and largely lacks national coordination and a defined research agenda. Key infrastructure exists in terms of national assets such as the Marine Institute and Environmental Protection Agency laboratories, together with Marine Institute run research vessels, while there is limited higher education institution laboratory space. A number of institutions are collaborating with European partners through more coordinated research programmes such as JPI-Oceans; however, in the main these projects are at an early stage e.g. microplastics and faecal contamination of bathing waters research.

### Research Topics

Effective measures proposed under the MSFD to address marine pollution and litter and achieve GES must be based on a deep understanding of marine ecosystem functioning. This requirement should translate into research to improve knowledge, monitoring and assessment operations. Such research will also ensure a strong evidence base for the characterisation of impacts including cumulative effects, and the effectiveness of management and mitigation measures, while positively contributing to the cyclical revision of MSFD measures. Similarly, the revision to the EU common understanding document on MSFD requires the development of agreed sub-regional (i.e. Celtic Seas) elements, criteria and associated threshold values for a number of descriptors. Amongst these, new elements and criteria will be required, notably relating to biological impacts, contaminants, litter and noise, all of which require a better understanding of the level of risk they represent to the environment. In particular, a better understanding of the interface between the freshwater and marine environment (land-sea interface) is required, together with an understanding of the impact of pressures on marine natural resources.

The need to ensure environmental sustainability to support the production of high quality food and other natural resource based products are drivers of research activity concerning marine pollution and litter. Major research areas associated with marine pollution and litter include understanding the sources, prevalence and incidence of contaminants, biological pollution, Non-Indigenous Species (NIS), noise, and litter at macro, meso, micro and nano levels; the impact of marine pollution and litter on marine environments, on coastal areas and on animal and human populations; and assessment, monitoring and mitigation (including treatment) methods, and strategies to obtain better spatial and temporal data upon which measures can be based. These are areas in which there is overlap with the Bioresources and the Biodiversity, Ecosystems & Food-webs themes.

### Focus of Funding

Given the variety of policy interests associated with the causes of pollution and litter and their impacts, an agreed research agenda amongst funding bodies is needed to maximise the value of research results under this theme. The transboundary nature of the pressures, their sources, pathways and impacts must be considered. Research topics include: human impacts on biodiversity; climate change implications for contaminant pathways; research at the land-sea interface to establish linkages between MSFD, WFD and Maritime Spatial Planning Directives; and the fate, transport and impacts of toxicants on human and animal health. Through coordination and/or co-funding of research topics, significant impact can be achieved to build research capacity and associated networks.

Ireland can rapidly build further research capacity in the area of pollution and litter by drawing on competencies from related research themes such as Ocean Observation and Seabed Mapping, Advanced Technologies and Information & Spatial Technologies, Analytics and Modelling. These include competencies contained within existing national structures

(academic research, sectoral research and development and marine, coastal and freshwater research programmes) and also from established food safety and environmental monitoring programmes. These capacities can be applied to improve our understanding of anthropogenic pressures and how to manage the risks posed by such pressures, including those associated with emerging contaminants, and micro – or nano-particles. Such an approach can be used to determine, for example, the origin of pollutants and litter, and the risks they pose to sensitive environmental niches, marine bioresources and the safety of seafood for sustaining animal and human health.

Of perhaps critical importance is the establishment of a risk based approach to the development of improved and effective spatial and temporal monitoring equipment for several areas within the Pollution and Litter theme such as contaminants and eutrophication.



# Climate Change

## Overview

Ireland's current capabilities in marine climate change<sup>1</sup> research provide a foundation for an area that is now a priority globally. Clusters of research activity with significant specialised expertise have developed within the Higher Education Institutions and a number of State Agencies. However, a lack of sustained funding for national climate monitoring networks and programmes and a need for increased inter-institutional collaboration has hampered the development of an established national capacity in this area, in particular in relation to the ocean component of climate change. A requirement also exists to engage with European and international research infrastructures, programmes and networks to maximise the impact of national investments in this area.

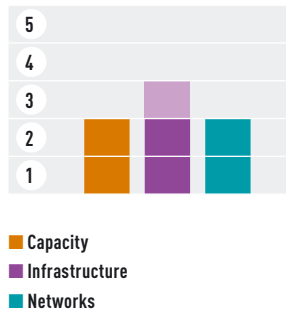
## Context

The **Fifth Assessment Report (AR5)** of the United Nations **Intergovernmental Panel on Climate Change (IPCC)** was completed in 2014 and contained extensive discussion and analysis of ocean warming, CO<sub>2</sub> emissions and related ocean acidification impacts. At **COP21**, all parties to the UNFCCC agreed an ambitious new legally-binding, global agreement on climate change (**The Paris Agreement**). In April 2016, the IPCC decided in the context of the Paris Agreement, to provide a **Special Report in 2018 on climate change and oceans and the cryosphere**. At **COP22**, the Marrakech Action Proclamation reaffirmed commitment to the full implementation of the Paris Agreement.

A range of international organisations are involved in advocating, coordinating and supporting climate change research. These include **CLIVAR** (Climate and Ocean: Variability, Predictability and Change - one of four core Projects of the World Climate Research Programme), **IOC** (Intergovernmental Oceanographic Commission), **GOOS** (Global Ocean Observing System), **Euro-GOOS**, **Copernicus** as well as the **MCCIP** (Marine Climate Change Impacts Partnership) in the UK. The **European Marine Board** produces important strategic policy documents in the form of the **Ocean-Climate Nexus Statement** and **Navigating the Future IV**. Both the **JPI Oceans** and **JPI Climate** have Strategic Research and Innovation Agendas. The **EPA Research Strategy 2014-2020** and the **Climate Action and Low Carbon Development Bill** (2015) are important for setting a national framework for climate change research and policy development.

Climate change research is also important in developing and monitoring indicators across a range of **EU Directives** such as Marine Strategy Framework Directive (MSFD) and Maritime Spatial Planning, as well as **international conventions** such as the OSPAR Commission.

<sup>1</sup> Climate Change is meant in its broadest sense and covers related impacts such as ocean acidification.



### Research Capabilities – Maturity Assessment

This research theme is assessed as being **“Defined”**. This is despite significant evidence of advanced levels of capability in relation to Human Capacity and Infrastructures. However, there is a lack of industry and policy-making engagement with this research capacity and in particular a lack of inter-institutional research clusters/centres.

### Research Topics

Given existing competencies and investments across the range of HEIs and state agencies, research topics should focus on retention of hard-won expertise and capacity, whilst leveraging increased collaborations within Europe and internationally.

The establishment and resourcing of long-term observation stations to measure current marine biological, chemical and physical parameters is a prerequisite baseline necessary to compare against climate change moderated biogeochemical scenarios. Research on climate change and ecosystems, including projected impacts, socioeconomic consequences and mitigation-adaptation strategies – focusing on coastal as well as offshore – should also be considered.

Given our shared sea area, it would be advantageous to deepen existing and develop new collaborations with relevant UK, European and international researchers, networks and infrastructures.

### Focus of Funding

Meaningful policy advice and the provision of climate change adaptation and mitigation options require a rapid progression to a “Collaborative” maturity level. Consequently, the key focus areas for funding include:

- *Supporting inter-institutional collaborative research through dedicated funding calls.* Research on climate change is highly interdisciplinary with impacts on a range of other research themes and topics in the marine, e.g. ocean observation, marine biodiversity, modelling, and the delivery of policy advice.
- *Establishing a research programme of scale in Ireland.* Such a programme should integrally link to sustained investments in an integrated ocean observing system (infrastructure). This is underpinned by key international, European and national policy drivers (COP21, IPCC, G7 Science & Technology Ministers, European Marine Board, JPI Oceans, EPA).
- *Increase strategic engagements with key European and international infrastructures and networks in order to add specific value to national investments.* This will increase collaborations with the wider global community and contribute to global goals on monitoring climate change impacts and mitigation strategies.



# Ocean Observation and Seabed Mapping

## Overview

Mapping, observing and predicting capacity is crucial for managing human activities and marine ecosystems in European seas and across the global ocean. The transformation of ocean and coastal observational data into products and services is a key element of this. Ireland continues to contribute to this theme, through the significant seabed mapping expertise and data acquired through INFOMAR, led by the Geological Survey of Ireland and the Marine Institute, and also through the development of key ocean observation and marine research infrastructure in Ireland. Irish researchers and industries also utilise remotely-sensed satellite data including European Space Agency (ESA) data. Such expertise and infrastructure is enabling researchers to advance our understanding of the ocean and coastal dynamics whilst in parallel facilitating innovation.

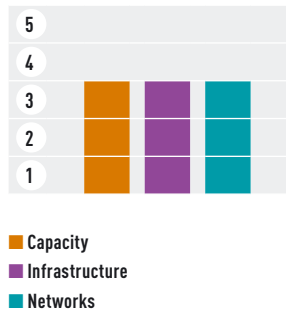
## Context

**A Framework for Ocean Observing** by the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012, seeks the co-ordination of ocean observations around “essential ocean variables (EOVs)”. The **Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC** (2010 Update) promotes a comprehensive observing system to measure “essential climate variables (ECVs)”, generate global analysis products; improve key satellite and in-situ networks; and strengthen national and international infrastructure.

A coherent assessment of good environmental status (GES) in European waters, which would include support for e-infrastructures for computing, modelling, forecasting and early warning systems, is a short term target of the **JPI Oceans Strategic Research and Innovation Agenda 2015-2020**.

**EuroGOOS** and the **European Marine Board** are leading an initiative called the **European Ocean Observing System**. **EOOS** is a coordinating framework designed to align and integrate Europe’s ocean observing capacity, promote a systematic and collaborative approach to collecting information on the state and variability of our seas, and underpin sustainable management of the marine environment and its resources. European Research Infrastructure Consortia (ERIC) such as the **EMSO** and **Euro-Argo ERICs** and the AtlantOS project are integral to the full implementation of EOOS. Ocean observation and seabed mapping are also key elements of the **EU Strategy for the Atlantic**, associated Action Plan and parallel initiatives such as the Galway Statement and **Atlantic Ocean Research Alliance**.

A key action of **Harnessing Our Ocean Wealth** is to develop and implement systems to provide real-time operating, surveillance and monitoring information on activity within Ireland’s maritime domain.



### Research Capabilities – Maturity Assessment

The overall Irish research capability in seabed mapping and ocean observation is assessed as **“Established”**. The nature of research in the field requires strengthening, particularly in relation to operational oceanography. Collaborative levels of infrastructure exist with nationally available equipment such as the Galway Bay cable, although Ireland’s in-situ ocean observation infrastructure is still somewhat limited. HEIs engaged in this research area are active internationally. There is also industry collaboration, but it is often fragmented in nature. In the state sector significant expertise is in place through the INFOMAR national seabed mapping programme and its predecessor, The Irish National Seabed Survey. Strong international linkages have been established e.g. through the Atlantic Ocean Research Alliance, the EMSO and Euro-Argo ERICs and EMODNET.

### Research Topics

There are four main business and policy drivers for ocean and coastal observation, these are:

- De-risking and supporting public, state and commercial operations in the marine sector by providing safe navigation data, and improving and integrating marine systems – coastal and seafloor geological mapping, biological time series, met-ocean observation, modelling of climate change and coastal dynamics.
- Enhanced flood and coastal vulnerability forecasting and mitigation systems.
- Developing new cost effective sensors, power systems, high bandwidth communications, data processing and data interpretation.
- Regulatory driven environmental monitoring. There already exist active Irish research groups in each of these areas, and these topics remain valid areas of focus.

In parallel, there is a requirement for additional research around the societal benefit of ocean observation and seabed mapping, through economic impact studies and enhanced understanding of ecosystem services by the coastal communities who derive benefit from them. There are significant linkages between this research theme, citizen science and those relating to Renewable Energy, Subsea Resources, Advanced Technologies, Climate Change, Integrated Policy and Governance, and Information & Spatial Technologies, Analytics and Modelling.

### Focus of Funding

A refocusing on operational oceanography skills and research is needed nationally to ensure that the basic skills required to support a range of other thematic areas is available. Ireland's vast marine territory requires a cohort of researchers and scientific staff who have the resources and expertise to deploy equipment in the ocean environment and analyse data on a long term basis. Similarly, Ireland's expertise in seabed mapping should be sustained and expanded by establishing appropriate undergraduate and postgraduate courses in an Irish Higher Education Institute. Earth observation and monitoring programmes should include a focus on downstream data and information services that promote partnership with industry.

The relatively developed research maturity assessment in this field masks a requirement for a range of funding supports in the ocean observation field to keep infrastructure up-to-date. Support for research infrastructure, primarily in the form of ocean deployed data acquisition platforms, is required. Given the complexity and cost of deploying ocean infrastructure, such infrastructure should be supported and facilitated at national level. Inter-institutional access and collaboration in using these infrastructures should continue to be encouraged through support instruments that facilitate research collaborations and formal inter-institutional centres.

There is a need for coastal and ocean observation products and services that meet legislative and resource management requirements. The further enhancement of interagency systems that provide real-time operating, surveillance and monitoring data on activity offshore Ireland can provide the base layer to which national agencies can add their specific data and make informed decisions. The provision of commercialisation supports can promote the establishment of linkages between researchers and private sector end-users of their data, products and services in this field.

Finally, involvement in international programmes that both support the above activities and provide access to infrastructure and expertise should be continued and developed.



# Engagement with the Sea

Recognising that our rich maritime heritage includes cultural, physical and ecological dimensions, *Harnessing Our Ocean Wealth* highlights the need for Ireland to raise our collective awareness of both the market and non-market value of the ocean.

Enhanced understanding does not in itself achieve engagement. **Ocean Literacy and Education** considers the way in which marine science, socio-economic impacts, policy choices and cultural significance are communicated to the public, including careful consideration of pre-existing cultural attitudes and behaviours. Similarly, innovations in how we provide education from primary through to postgraduate level are vital to ensure that young citizens of today value and care for our marine environment, and are equipped to work in the marine economy.

The marine environment is diverse, and such diversity brings with it challenges in terms of governance and policy development. Policy decisions can rarely be taken regarding one aspect of the marine or maritime governance without impacts on another. In order to facilitate the best possible use of the information generated in the range of research themes considered in this strategy, a further set of innovations are required in the form of an **Integrated Policy and Governance** theme. This theme is required to ensure that there are suitable frames of reference in terms of *Socio-Economics, Legal Frameworks, Planning & Governance* and *Business Development*. These four topics are themselves at varying stages of development in the Irish context. As a result these topics are assessed in terms of maturity separately.

The management and interpretation of new information and the ability to process it into knowledge products is an evolving challenge in the marine context. Fortunately, Ireland is well placed to use advanced skills and research capabilities in the area of **Information & Spatial Technologies, Analytics and Modelling**. Despite this capability it must be “marinised”, as highlighted in the report of the Development Task Force.

Finally, in order to achieve full engagement with the sea, society must be able to access it beyond the shoreline. The ocean environment, for all its potential and value, is a harsh and challenging environment. **Engineering** capability, and the ability to produce engineering innovations in response to this environment, is a fundamental requirement for achieving the ambitions set out in *Harnessing Our Ocean Wealth*.

Together, the topics of Ocean Literacy & Education; Integrated Policy & Governance; Information & Spatial Technologies, Analytics and Modelling; and Engineering also form a broad platform for the development of both a thriving maritime economy and future healthy marine ecosystems.



# Ocean Literacy & Education

## Overview

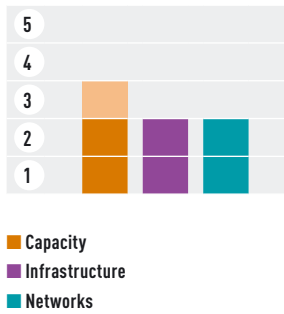
The term ocean literacy relates to our understanding of the ocean's influence on society and society's influence on the ocean. Ocean literacy is about improving education and citizen and community awareness, knowledge and engagement, promoting the value of the ocean; as well as equipping citizens to make informed decisions in relation to the marine, forming a better governance of the sea and ensuring that the skills required for the ocean economy are in place. Ocean Literacy spans the broad areas of formal and informal education and training and a range of outreach activities. Research activity is emerging nationally in the area driven primarily through collaborative EU projects. There is also a drive to ensure outreach activities are built into marine research projects and larger initiatives. Specific training and education programmes that encourage knowledge of issues related to the ocean (at all levels of education and training) are required. This includes programmes to 'marinise' graduate and vocational training programmes.

## Context

On a global and European scale there is a strong emphasis on building an ocean literate society. This has been the focus of **UNESCO** and its Intergovernmental Oceanographic Commission (IOC), across transatlantic programmes such as the "Galway Statement on Atlantic Ocean Cooperation, 2013" (linked to the **EU Atlantic Action Plan**), the **EU Horizon2020** Programme. The EU's **Integrated Maritime Policy (IMP)**, which aims to raise the visibility of Europe's maritime identity and economic potential among Europeans, also identifies the need for collaboration and innovation to reduce the growing skills gap relating to the marine and education at all levels. The EC's focus on **Innovation in the Blue Economy**, including the subsequent Communication on **Careers in the Blue Economy**, and recent funding targeted at Blue Careers, are important aspects of the EU's IMP and Blue Growth initiatives.

The "Engagement with the Sea" goal of *Harnessing Our Ocean Wealth* aims to *strengthen Ireland's maritime identity and increase awareness of the value, opportunities and social benefits of engaging with the sea*. It recognises the need for inclusive stakeholder participation as well as recognising the importance of a skilled and experienced workforce, the need to identify future skills needs and labour market demands, in tandem with adapting and developing education and training programmes. It also includes a number of actions aimed at raising public awareness and knowledge of our marine resources and maritime heritage. The related report of the **Development Task Force**, identifies the necessity to "marinise" existing enterprise sectors into marine markets and also recommends the development of a pipeline of skills and intellectual property to sustain continued growth

in Ireland's ocean economy. The Enablers Task Force on **Maritime Spatial Planning (MSP)** recommends an active participation by all stakeholders and the general public from the outset of the planning process. The **Expert Group on Future Skills Needs (EGFSN)** report provides a number of conclusions and subsequent actions related to ocean literacy. These include establishing a Marine Discover Programme aimed at raising awareness among students (at all levels). This will build on existing initiatives such as the Marine Institute's primary school Explorer's Programme. The report also identifies the importance of ship-based training as provided by the SMART programme.



## Research Capabilities – Maturity Assessment

This research theme has been assessed as **“Defined”**, albeit close to being at the “Established” level in relation to Human Capacity. Researchers are primarily from social and economic sciences involved in EU projects, with strong international collaboration. Various national projects and initiatives ranging across computer science, social innovation, oceanography, science education and socio-economics also exist. SFI funded research centres continue to actively engage in a range of outreach activities across all levels of society.

A range of marine-focused education and training programmes exist across all levels of education, with the focus predominantly on primary and tertiary education. In excess of 40 courses are provided by Ireland’s Higher Education Sector at undergraduate and postgraduate level that are either fully marine or have specific marine modules. Ireland’s public and private sectors also offer a range of innovative vocational and continuous professional development and sector-specific training to national and international clients.

Communities of interest exist with varying degrees of access to facilities and active research projects. There is a need to further develop research programmes ensuring collaboration with industry, State Agencies and Higher Education Institutes.

## Research Topics

At a national level, research is required to support and assess all the relevant actions from *Harnessing Our Ocean Wealth* that are linked to its third goal of “Engagement with the Sea”. Interdisciplinary research, in particular research in topic areas that span the humanities and social sciences and science, as well as technology and engineering disciplines is central to this. This includes those that investigate understanding and dissemination of knowledge in the broad area of the ocean and the impact this has on citizens. Research Topics in this theme also cross over into the multidisciplinary research theme of Integrated Policy and Governance.

Actions that support the findings of the Expert Group on Future Skills Needs are also required as well as engagement and collaborations with key stakeholders including Government Departments, State Agencies, HEI’s and industry in order to develop research through formal and informal education as well as citizen science and outreach.

The scope of Horizon 2020 funded projects provide opportunities to cover a broad area of ocean literacy including environmental status, pollution affecting marine biodiversity and ecosystems, education and citizen science with an aim to disseminate information and engage key stakeholders and the public at large.



## Focus of Funding

Engaging with Government Departments, State Agencies, Higher Education Institutions and industry (with a marine and/or a formal education remit) to support the cross-cutting nature of ocean literacy is required to maximise funding. A national Ocean Literacy Programme should build on expertise generated in EU Horizon 2020 projects, as well as building on national educational programme initiatives to further efforts to integrate marine into the Irish education system from primary school level through to secondary and beyond.

Support for a community of interest among Irish researchers and businesses is emerging and a national coordinator would enable these researchers to better compete for funding from Horizon 2020 and other international funding programmes. This would also help increase the capacity and number of researchers active in this area. As Ocean Literacy is cross-cutting, many existing sectors will benefit from extending into marine-related areas.

Specific training and education programmes that encourage a familiarity with issues relating to the ocean, both from an environmental protection and sustainable development viewpoint are required. In particular, programmes to “marinise” graduate and vocational training should be supported.



# Integrated Policy and Governance

## Overview

As our marine resources become increasingly viewed as the basis for a 'blue economy', the sustainable development and management of our seas, oceans and marine and coastal resources increasingly requires a holistic and integrated system of governance. The need for integration and cooperation is increasingly recognised at the varying national and international levels of governance of our oceans.

Research and innovation has a major role in supporting the development of both sectoral and the integrated marine policy agendas, at national, EU and international level. Research is essential in supporting societal challenges and cross-cutting priorities such as food security, climate change and sustainable development, but can also provide solutions, evidence and knowledge for governance of our vast marine resource, as well as the services and enterprises associated with it.

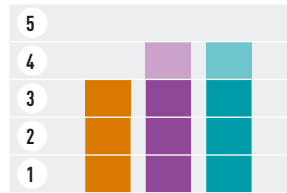
## Context

With the increased focus on our oceans, there is a growing realisation of the necessity for increased collaboration, cooperation and innovative governance of the oceans and the activities that it supports.

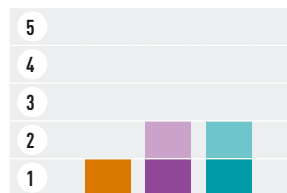
This is evident in a wide range of treaties, conventions, agreements and policies at international, EU, regional, national and local level, where ocean governance is recognised as essential for the sustainable management of our global

seas e.g. at international level – the 1982 **UN Convention on the Law of the Sea** (UNCLOS); at EU level – the **Integrated Maritime Policy**, the **Common Fisheries Policy**; at international 'sectoral' level – the work of the **International Council for the Exploration of the Seas**, the **International Maritime Organisation**; and at a national level – **Ireland's Integrated Marine Plan – Harnessing Our Ocean Wealth**, and related initiatives such as **Maritime Spatial Planning** and the work of **the Development Task Force**.

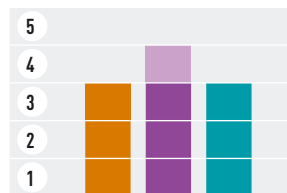
### Socio Economics (Established)



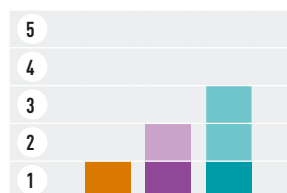
### Legal (Ad-Hoc)



### Planning & Governance (Established)



### Business Development (Ad-Hoc)



█ Capacity  
█ Infrastructure  
█ Networks

## Research Capabilities – Maturity Assessment

To address the challenges and capabilities required to support integrated marine policy and governance as highlighted above, the ‘Maturity Assessment’ has been categorised into four broad research themes. The assessment addresses each of these themes in the context of current, planned and potential.

### Human Capacity

Current research capabilities and initiatives in the disciplines related to policy development and governance are found in a number of institutions and state organisations. In the Higher Education sector, collaboration in the SFI centre for Marine and Renewable Energy (MaREI) has significantly enhanced the need for multidisciplinary and applied research. In the State sector, scientific, technical, legal and economic capacity and expertise is available (although limited) across a number of state bodies and Government Departments.

The capacity ranges from “Ad-hoc” in respect of Legal, and Business Development, through to “Established” in the area of Socio Economics and Planning & Governance. Although a number of high-profile researchers are involved in a range of research activities supporting integrated policy and governance, the primary concern is the critical mass required to fully develop and manage Ireland’s ocean wealth to its full potential. In some areas, for example in the areas of Planning & Governance and Business Development, dedicated capacity and capability is planned in the state sector to address capacity required to develop a Maritime Spatial Plan for Ireland and also recommendations related to the report of the Development Task Force, e.g. the establishment of an integrated Marine Development Team.

### Infrastructure

A range of education and training offerings are provided across the Higher Education sector on the island of Ireland that are relevant to the management and governance of Ireland’s ocean

wealth. Multidisciplinary courses are delivered at undergraduate (UG) and postgraduate (PG) level in the areas of Marine Science, Earth and Ocean Science, and Environmental Science. At postgraduate level a number of courses have distinct or partial marine modules.

Spread across HEIs, a vast range of courses are also applicable to educating and training future researchers and practitioners in the area of integrated marine governance. This includes dedicated courses in Maritime Spatial Planning (PG), as well as more generic courses in planning, environmental and resource management (UG and PG).

Over the last decade, Ireland’s capacity and capability to collect and report on data (economic, biological, environmental and social) has strengthened. The ability to translate this data into a format that can fully support the integrated governance of our seas and oceans still requires further support and innovation. The further development of key data infrastructures and associated models (specifically in the area of socio-economics) is still at an early stage. Data gaps exist in a number of sectors. Other key data infrastructures include Ireland’s Marine Atlas.

### Networks

Various policy and governance forums operate at a national, EU and international level. These open innovation forums allow for the engagement of a range of stakeholders spanning research, industry, NGO’s, scientists, policy makers and the general public. Irish experts have a strong track record of informing and advising on sectoral and marine policy areas e.g. through forums such as ICES, OSPAR, UNESCO, EU expert groups, regional fisheries forums, and targeted task forces.

A number of sector-specific or multi-sector researcher/policy/stakeholder forums are already gaining significant momentum in Ireland. These include the structures set up under the Offshore Renewable Energy Development Plan (OREDPP), the annual Marine Renewable Industry Association Event, the annual Law

and the Environment Conference (with dedicated maritime law sessions), the annual Beaufort Marine Socio-Economic Workshop, the annual Ocean Wealth Conference and related events.

## Research Topics

*Business, Innovation & Socio-Economic Development:* The Integrated Marine Plan for Ireland comprises an ambitious series of targets and initiatives, the successful realisation of which entails a significant upscaling of information collection and processing capability as well as the initiation of a series of measures to support and drive business development in the marine sector.

*Planning, legislation & integrated governance (including regulation):* Forward looking economic, social, and legal research and planning are required to identify emerging opportunities, assess the adequacy of existing legislation and planning mechanisms and enable government departments and development agencies to establish fit-for-purpose processes.

*Public Sector Innovation:* Achieving the objectives of Harnessing Our Ocean Wealth entails an ongoing process of awareness-raising across the public and private sectors of the opportunities for marine resource development, as well as a progressive upgrading of public sector capabilities to manage the research, business development and associated governance and regulatory procedures entailed. Continued enhancement of community and stakeholder involvement in the development and management of marine resources, including the ongoing establishment of maritime spatial planning procedures, will be an essential dimension of the wider potential impact of this strategy and will benefit from

the collaboration and joint actions between agencies and institutions that is a core feature of the Strategy.

## Focus of Funding

Actions to support the topics above include:

- Building/supporting 'centres of excellence' with complementary skills across the HEI and State sectors.
- Promoting collaborations between these centres of excellence, agencies and other national organisations to enhance innovation in the areas of socio-economics and planning, governance and business development.
- Commissioning and promoting relevant high-level studies on policy issues in the marine sector.
- Examining the current and planned policy framework in order to consider the best organisational structures for engaging with stakeholders on an on-going basis at the appropriate scale.
- Developing a fully comprehensive and internationally compatible suite of progress indicators, socio-economic targets and ecosystem services valuation.
- Continuing to build social and economic impact assessments of the ocean economy and associated plans and policies (current and potential).
- Strengthening agency capabilities to utilise and add value to data collected for routine/statutory purposes.
- Strengthening the capabilities of the State to support the work of the Marine Coordination Group, to implement commitments under Harnessing Our Ocean Wealth, and to implement key sectoral policies, e.g. the Common Fisheries Policy and the Offshore Renewable Energy Development Plan.
- Commissioning research to better integrate enterprise opportunities arising from, currently, largely autonomous and unconnected sub-sectoral development plans e.g. aquaculture, fisheries, oil and gas etc.



# Information & Spatial Technologies, Analytics and Modelling

## Overview

Ireland has a strong presence in global information technologies via the presence of major Foreign Direct Investment and active indigenous companies and innovation. The Digital Ocean identity for Ireland is a developing one with active public sector engagement and established research and teaching institutions. This concept, which broadly encompasses Information & Communications Technology, Geographic Information Systems, data analytics and data and numerical modelling, represents a foundation set of disciplines for progress in many of the other themes in this strategy. Marine-related research in this area will be driven by the requirements emerging from areas such as public policy (in particular maritime spatial planning), climate change, and ocean observation and seabed mapping.

## Context

The adoption of information and also location technologies is the subject of national strategies and European and global initiatives. These include, for example, the **Public Service Reform Plan** and the **Public Service ICT Strategy**. These national e-Gov approaches are informed by EU policies and strategies including the **European Digital Single Market Strategy**.

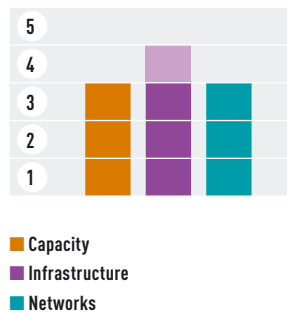
In a marine context, Ireland is an active member of **EMODNET** – The European Marine Observation and Data Network – a network of organisations supported by the EU’s integrated maritime policy. Organisations work together to assemble marine data and metadata according to international

standards and make that information freely available as interoperable data layers and data products. **EMODNET** provides access to European data across the areas of bathymetry, geology, seabed habitats, chemistry, biology, physics and human activities.

Systems and services are also being developed at European level that support or facilitate national activities, for example the **European Space Agency Sentinel observation platforms**, and the Copernicus Programme **Marine Environment Monitoring Service** (CMEMS). The marine and space domains have strong parallels providing opportunities for knowledge transfer and capacity building.

Statutory aspects such as the **INSPIRE** and **Re-Use of Public Sector Information EU Directives** promote and provide regulatory basis for open data and cross European harmonised datasets.

Ireland’s enterprise policy **Enterprise 2025** identifies “Marine” and “Green Technologies” as sectors where potential is untapped. Enterprise development plans and support are extensive in the broad ICT area; however, as acknowledged in the report of the **Development Task Force**, focusing on “marinising” existing products and services is leading to an increased focus on spin-in and spin-out companies in marine sectors including marine ICT.



## Research Capabilities – Maturity Assessment

This research theme is firmly at the **“Established”** level with strong potential to grow to the “Collaborative” level with the research capability already participating in large-scale research centres, particularly in relation to renewable energy and the geosciences, together with significant data infrastructures such as the INFOMAR data set. Progression to the “Collaborative” level will require concentration of effort to apply this capability to the broad marine domain. In particular securing industry participation, from the predominantly SME based marine sector, in research centre initiatives is a particular challenge.

### Research Topics

As data streams grow, and access to them simplifies, the opportunities for research focused on use cases to support policy decision making will grow. Applied research, focusing on data integration, analytics and visualisation will have particular application in areas such as maritime spatial planning, ecosystem modelling and understanding the cumulative effects of anthropogenic activities.

Numerical modelling and simulation, which itself generates data streams, is closely aligned with the Ocean Observation and Seabed Mapping theme, providing as they do foundation data for many of the themes in this strategy. The ability to downscale from the large grid sizes of global and regional models, and to improve the predictive capability and computational efficiency of coastal oceans models is a key area of importance for Ireland.

Building on data from such models, together with in-situ monitoring, there is an opportunity to build data analytics capability. This, combined with the test labs, instrumentation and sensors in MaREI, the SmartBay observatory and elsewhere, will provide commercial opportunities for marine sensor and data products.

### Focus of Funding

The research capability maturity assessment for this research theme indicates that there are opportunities to leverage a number of research infrastructures to increase the capability in terms of human capacity and networks and relationships. Examples of such leveraging would include providing support to key institutions and networks to be placed on the ESFRI Research Infrastructures Roadmap and utilisation of European Space Agency funding opportunities to promote Irish-led marine Earth Observation and ICT projects. Promoting entry to consortia involved in Horizon 2020 and future EU framework programmes could be promoted through support of ERANet or Joint Programming projects, together with international mobility awards.

There is a continuous need to ensure access to, and build capacity in, computational infrastructure for use by computationally intensive applications such as numerical modelling and some data visualisation problems. Applied research into the high performance computing and associated hardware, software and algorithms to increase a computational efficiency of such models can play a role in this capacity development.

All aspects of this theme will be strengthened through efforts to highlight the challenges of the marine domain to undergraduate and postgraduate students in mathematics, computer science and information technologies.

Given the applied nature of much of this research theme, there is also scope for the provision of non-technical financial and management support to spin-outs to ensure commercial fundamentals are stable while delivering on innovation. Similarly, innovation support at high-risk stages of product and service development should be provided. The use of Small Business Innovation Research (SBIR) can have an important role in this regard, as can small scale innovation support provided by large scale monitoring and data acquisition programmes. An example of the latter kind of support is that provided by the INFOMAR programme in recent years.



# Engineering

## Overview

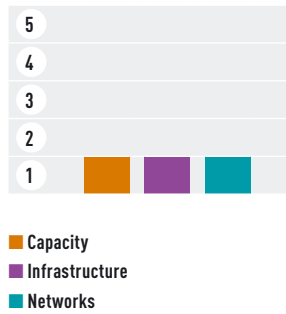
A myriad of core engineering disciplines support coastal/offshore projects. Ireland is well served by the third-level sector, which produces upwards of 500 engineering graduates annually. Engineering disciplines are involved, and reflected in, the capability of a range of other research themes such as Advanced Technologies, Renewable Energy, and Information & Spatial Technologies, Analytics and Modelling. However, marine engineering activity in Ireland is at a relatively low-level; linked to a low-level of activity in many areas of the ocean economy.

The establishment of a new integrated Marine Development Team, as recommended by the report of the Development Task Force, will begin to tackle the significant industrial development challenge.

## Context

The study and investigation of engineering systems operating in the maritime environment underpins Goal 3 in **Harnessing Our Ocean Wealth** to strengthen our “Engagement with the Sea”.

The cohesive set of recommendations from the **Development Task Force** included “Demonstrating Intent”, which is centred around supporting demonstrator projects that fit within the report’s “Marinising / Strengthening / Developing” Strategic Framework. Engineering capability in the fields of structures, energy conversion, naval architecture and design for the sea will be needed for demonstrator projects.



## Research Capabilities – Maturity Assessment

Of all the research themes examined in preparation for this strategy, the Engineering theme was the least defined, and by default is assessed at the “Ad-hoc” level. This is not reflective of the level of engineering expertise available in Ireland, nor indeed of the level of engineering research. It does, however, point to the very low level to which this expertise and research capacity is applied to the marine sphere.

### Research Topics

Engineering capability in the fields of structures, naval architecture and design for the sea, as well as power and control systems, will be needed to support the development of a number of the research themes, as well as for a range of the proposed demonstrator projects identified in the **Development Task Force** report, namely:

- Frontier Aquaculture (Food from the Sea)
- Marine Renewable Energy Devices & Arrays (Energy from the Ocean)
- Marine Engineering (Energy from the Ocean)
- Ocean Racing Yacht Platform (Enterprise & Industry)
- Offshore Platforms End-of-life Services (Enterprise & Industry)

A specific area, in which Ireland has significant generic expertise, is engineered structures, including concrete, steel and other fabrication methods. Development of research expertise on the enhancement of survivability of structures in the marine environment for use in aquaculture, ocean energy and subsea infrastructures is warranted.

### Focus of Funding

The focus of funding and support for engineering in marine areas is primarily needed to establish a basic level of capacity and recognised expertise that can draw on strengths in related areas, such as ocean energy and marine geosciences.

Funding is needed to support the transfer and extension of engineering capabilities that are currently focused on land-based activities in Ireland.

Support for the “Integrated Marine Development Team” and the delivery of the demonstrator projects identified by the Development Task Force will be needed and a key step will be the effective networking of the currently fragmented marine engineering sector.





# Funding Instruments

The insights from the analysis of available funding instruments indicate that careful consideration of the instruments that are made available to each research theme is required to achieve impact. In order to identify these, the Research Capability Maturity Model developed in conjunction with this strategy provides a useful frame of reference. For instance, where a research theme has advanced capabilities in terms of human capacity and infrastructures, but is failing to perform at an international level because of a lack of international collaborations and networks, the focus of funding should be aimed at supporting the research base to engage with, and gain access to, suitable consortia.

The analysis has identified those existing national funding instruments that can be utilised to advance the themes' maturity levels for the Human Capacity, Infrastructure and Networks & Relationships dimensions of the Research Capability Maturity Model, or gaps where new funding instruments are required. The results of this analysis are reflected in Tables 1, 2 and 3 below, which show examples of such instruments, or, in the absence of examples, where gaps exist.

In addition to these national funds, there are a range of supports available under EU Programmes such as Horizon 2020 and joint programming initiatives.

Table 1: Instruments for Capacity Development

Transition	Description of types of suitable supports	Existing Examples	Typical Cost over lifetime of award
Translational ↑ Collaborative	Commercialisation Support	DAFM “Research Plus” award	≤ €100,000
	Awards to promote links to industry	IRC “Enterprise Partnership Award”	≤ €100,000
Collaborative ↑ Established	Awards to promote research excellence	IRC/MSCA “CAROLINE” award	≤ €300,000 (Co-funded)
	Awards to promote links to industry	IRC “Enterprise Partnership Award”	≤ €100,000
	Awards to promote policy engagement with research	IRC “Research for Policy” award	≤ €100,000
	Awards to promote policy engagement with research	IRC “Research for Policy” award	≤ €100,000 (Co-funded)
	Awards to build teams around Principal Investigators	SFI “Investigators” award.	€400,000 to €2.5m
Established ↑ Defined	Awards to build teams around Principal Investigators	Co funded SFI “Investigators” award.	€400,000 to €2.5m (Co-funded)
	Awards to build teams around Principal Investigators and marine research infrastructures	Marine Institute Research Cluster Awards	€300,000 to €2m
	Awards to potential and early stage Principal Investigators	SFI “Starting Investigator Research Grants”	≤ €400,000
	Awards to facilitate focus on research topics within HEI sector	Geological Survey “Griffith” awards for teaching buyout	≤ €100,000
Defined ↑ Ad Hoc	Undergrad training programme support	SMART Programme	≤ €300,000
	PhD Scholarships	Marine Institute “Cullen” Awards	≤ €100,000
	Project based Principal Investigators, e.g. Research Fellowships	DAFM “Standard” Project	≤ €300,000
		Geological Survey Postdoc Fellowships	≤ €225,000
		Marine Institute Project Based Awards	€300,000 to €650,000
	Awards to potential and early stage Principal Investigators	SFI “Starting Investigator Research Grants”	≤ €400,000
	Desk Studies and Research Masters	DAFM “Small Project”	≤ €100,000
		Geological Survey Short Calls	≤ €25,000
	Awards to promote awareness and knowledge	Marine Institute Medial Awards	≤ €100,000
	Support for undergraduate training programmes	SMART Programme	≤ €300,000

## Commentary

In the model used in this strategy, the most advanced level of research capability is referred to as “Translational”, and in terms of human capacity this implies active participation in commercial product creations and/or policy formulation.

The supports required in this area are focused on fostering both industry collaboration and policy definition from the research base.

At the “Collaborative” level, the research base in a particular theme should be capable of operating in an international arena, which implies numbers of senior researchers who are recognised as providing some degree of leadership in their field.

Accordingly, research supports that promote movement from the “Established” level to “Collaborative” are focused towards supporting research expertise both in terms of the individual researcher, through international mobility awards, and the capacity around that researcher in terms of research teams. In respect of the mobility awards there is some overlap in the instruments used in the development of the “Networks & Relationship” dimension.

The “Established” level reflects a research community that has the security to pursue research themes over timeframes that extend beyond individual project awards. In order to do this, Principal Investigators should have established positions, enabling the pursuit of funding awards that focus on the research teams that are gathered around them. An immediate route to this is to broaden the research fields of already established personnel into marine-related areas.





An example of such a mechanism is the SFI Investigators Programme. This programme indirectly incentivises HEIs to establish Principal Investigators which can then be leveraged to receive funding for large research teams. At this level, co-funding by sector specific agencies can promote a particular focus such as marine.

Research themes at the “Ad-hoc” stage rely on the work of individuals operating outside of recognisable communities of interest. Instruments to develop this capacity therefore should focus on developing the numbers engaging with the theme in a coherent manner. This can be achieved by developing the resources of those already working in the field, or by attracting new participants.

Suitable instruments include support to HEIs to promote teaching in the area, PhD scholarships, project-based Principal Investigator awards, and awards to high potential early career researchers.

Very early stage themes, such as new fields that require a rapid response to build a research base can benefit from instruments such as desk-studies at Master’s Degree or Doctorate Level, Scholarships and awards to HEIs to promote teaching in the area.

Table 2: Instruments for Development of and Access to Infrastructure

Transition	Description of types of suitable supports	Existing Examples	Typical Cost over lifetime of award
Translational  Collaborative	Supports for National Research Centres	SFI Research Centres	≤ €6m – €30m
	Supports to establish “Best in EU” class infrastructures	SFI Infrastructures Call	€200,000 to €500,000
	Supports to develop Post-Doctoral training Programmes		≤ €300,000
	Supports to fund National Test & Demonstration facilities	SFI Infrastructures Call	€500,000 to €3m
	Supports to fund access to National Test & Demonstration facilities	MI SmartBay Access Programme	≤ €50,000
	Supports to fund prototyping	SEAI Ocean Energy Prototype award	€50,000 to €1.5m
Collaborative  Established	Funding for national equipment pools		€10,000 to €200,000
	Supports to fund access to National Test & Demonstration facilities	MI SmartBay Access Programme	≤ €50,000
		Marine Institute Ship-time Access Programme	€200,000 to €500,000
	Supports to develop Post-Doctoral training Programmes		≤ €300,000
	Supports to develop Post Graduate training Programmes		≤ €200,000
	Supports to encourage participation in EU Infrastructure Networks		≤ €50,000
Supports to fund prototyping	SEAI Ocean Energy Prototype award	€50,000 to €1.5m	
Established  Defined	Funding for purpose built laboratory space		≤ €3m
	Supports for the acquisition of specialist equipment		≤ €200,000
		SFI Research Infrastructure awards	≥ €200,000
Defined  Ad Hoc	Support for the development/expansion of Undergraduate and taught Post Graduate training programmes,		≤ €150,000
	Co-funding of HEI/RPO equipment acquisition		≤ €50,000



### Commentary

At the “Collaborative” level, research infrastructures are supporting Irish research to attain best-in-class recognition at a European and International level. Moving to “Translational”, the focus of investment in infrastructure is tied to the development of Human Capacity and Network & Relationship dimensions. This will enable meaningful support across both policy decision-making and enterprise development.

To move research themes from the “Established” to the “Collaborative” levels in the Infrastructure dimension, supports are required that ensure the national availability of equipment and the inclusion of national infrastructures in EU wide infrastructure networks. This will require a nationally coordinated approach to such equipment as individual HEIs/RPOs may not be in a position to best identify the requirement for infrastructure.

At this level, research excellence is only one consideration and strategic imperatives, such as the requirement for policy advice, need to be considered.

In this transition, research themes see the emergence of centres of excellence and levels of inter-institutional collaboration. In particular, facilities, equipment, and knowledge-support platforms are made available to advance the Human Capacity and Networks & Relationships levels.

A number of research themes register low across all the dimensions of Human Capacity, Infrastructure and Network & Relationships. These themes also require investment in terms of teaching capacity in order to develop a means to provide future human capacity, coupled with modest equipment purchases and facilities. In a few instances, there are required infrastructures in place. However, where these are not being adequately utilised in either a training or research setting a collaborative funding approach is required to incentivise the relevant institutions to pursue more active usage. Similarly, support for the acquisition of new equipment generally should be pursued on a collaborative basis.

In the case of very early stage research themes, a key intervention is to support existing undergraduate courses to add marine-related electives or modules to their programmes. In addition, the establishment of post graduate training programmes to allow graduates pursue a marine career is desirable.

Table 3: Instruments for Developing Networks &amp; Relationships

Transition	Description of types of suitable supports	Existing Examples	Typical Cost over lifetime of award	
Translational ↑ Collaborative	Awards to promote leadership roles in inter-governmentally mandated science organisations		≤ €75,000	
	Awards to promote leadership roles in industry standards		≤ 75,000	
	Awards to promote coordination roles in international networks	DAFM “Thematic Coordination Network”	≤ 150,000	
	Awards to promote linkages between research and commercialisation	EI Commercialisation Fund EI Innovation Hub Awards	€80,000 to €350,000 ≤ €3m	
Collaborative ↑ Established	Awards to promote significant levels of inter-institutional research collaboration	DAFM Programme Awards (4 RPOs)	≤ €3m	
		DAFM Large Project Awards	≤ €1.25m	
	Awards to promote industry collaboration in research theme definition	SFI Partnership Programme	≤ €350,000	
		SFI Research Centres EI Technology Centres	≤ €1m to €5m ≤ €5m	
Awards to promote policy engagement with research	IRC “Research for Policy” award.	≤ €100,000 (Co-funded)		
Established ↑ Defined	Awards to promote inclusion in established communities of interest participating in H2020/Framework Programmes	Marine Institute funded Joint Programming Initiative (JPI Oceans) calls	≤ €1.5m	
	Awards to promote industry collaboration	SFI Industry Fellowship	≤ €100,000	
		EI Innovation Partnership	≤ €250,000	
	Awards that promote inter-institutional collaboration	DAFM Large Project	≤ €1.25m	
	Awards towards the hosting of international conferences		≤ €50,000	
Awards that promote recognition of researcher excellence at an international level	Marine Institute Fulbright Awards	≥ €25,000		
Defined ↑ Ad Hoc	Awards that promote the establishment of communities of interest	DAFM Standard Project	≤ €600,000	
	Awards that promote participation in H2020/Framework proposals	IRC New Horizons Programme	≤ €220,000	
	Awards that facilitate interaction with international communities of interest.	EI/MI Travel Awards	≤ €10,000	
	Awards that encourage contacts between research Institutions	DAFM “Desk Study”	≤ €200,000	

## Commentary

In general terms, the transition from “Collaborative” research to “Translational” research requires high levels of industry and policy interaction, the development of IP frameworks and international leadership at the inter-governmental level.

The practices that were identified in the “Established” level with regard to Networks & Relationships are strengthened and developed at the “Collaborative” level. In particular, the involvement of industry and policy making interest move from participation to theme definition. Similarly, the level of collaboration becomes far more cohesive from a national perspective to a point where Ireland is recognised as a leader in a research theme as distinct from individual research performing organisations.

The “Established” Level for any given research theme implies a functioning national research system that has commenced confident participation in transnational projects. It also implies that the theme in question has commenced the transition from academic-led research to collaborative research with industry and policy making organisations. Achieving a transition to this level of participation requires supports that promote large-scale inter-institutional collaborations, create structured linkages with industry and policy making partners and ensure participation in international consortia.

This last type of support is of crucial importance as inclusion in consortia for programmes such as Horizon 2020 is primarily based on track record and supports such as networking grants will not achieve this. In this regard, co-fund opportunities such as those provided by Joint Programming Initiatives ensure Irish participation in consortia that can become established over the longer term.

The key feature of the “Defined” level from a Networks & Relationships perspective is the existence of identifiable, active, communities of interest. Supports that can encourage such communities include medium-scale awards that bring research performing organisations together to collaboratively address a particular research problem or to participate in transnational networks. Also applicable in this category are smaller-scale awards such as travel awards and awards for hosting and attending conferences and workshops.

In the case of very immature research themes, the main action is to make active research networks aware of marine-related research possibilities. This is ideally achieved through encouraging cross-disciplinary contacts between research communities already involved in the marine sphere and those not, for example engineering and aquaculture research teams. Small-scale interventions, such as desk studies, that require diverse expertise can achieve this goal.



# Implementation

In the Statement of Strategy, three main goals were articulated.

The **first goal** is to **raise the research capacity** across all themes.

The **second goal** is that **research funding should be targeted**, within the overall goal of raising research maturity, to topics matching requirements articulated in state **policies and sectoral plans**.

The **third goal** is that there should be **coherence in the approach to marine research by the various state actors** involved in funding marine research.

Delivery of these goals will require a variety of state bodies to work together to ensure that research topics are prioritised, funding is aligned, research capabilities are raised, and the usage of national research infrastructures is maximised. Further discussion and related actions to achieve this are set out below. These actions have been aligned to Innovation (I2020).



# Alignment of Funding

A range of funding instruments for research exists across the Irish public funding system. These are summarised in **Ireland's Research and Development Funders** report published by Science Foundation Ireland. An analysis of these instruments as presented reveals the following insights:

- The majority of funding instruments are relevant to research themes that are at the “Collaborative” Level or “Translational” Level. As the review of the research themes has concluded that the majority of themes are at the “Established” Level (or lower), the consequence of this is that for the most part, marine researchers will not be in a position to compete for these instruments.
  - There is a significant disparity between the numbers of instruments that have a clear enterprise application, and those that are more relevant to informing public policy.
  - There is a range of networking supports; however, the majority of research themes underperform in the Networks & Relationships dimension. This indicates that these instruments may promote access to meetings with potential collaborators, but are not sufficient to gain access to collaborative projects. Of the supports that are available, the research base in Ireland is often not well enough established to take advantage of them.
  - Many of the research supports include conditions that presuppose an advanced level of maturity. In the case of marine-related research themes this is not always the case. For example, the scale of marine industries, which is characterised by a high number of SME and micro-SME companies, provides challenges in achieving the level of financial support often required for research funding.
- A range of agencies and line divisions in government departments are actively engaged in providing the supports required. Some gap areas exist; while in others increased focus on the marine dimensions of a particular research theme can be achieved through advice or co-funding. Agencies with specific technical and scientific expertise such as the Marine Institute, the Geological Survey of Ireland and the Environmental Protection Agency have a particular role in this regard.
- In order to address these gaps and enable cooperation through co-funding and other mechanisms, a forum for those funding marine-related research should be established.

Action	Description	I2020 Action
1. Marine Research Funders Forum	Convene a research funders forum for organisations funding marine-related research themes.	4.17

# Raising Research Capacity

It is a well-established principle of public funding for research that investments made yield benefits for society, both in terms of development of enterprise and informing public policy<sup>2</sup>. Furthermore, the more developed the research base for a theme is, the more impact that theme is likely to have. With this in mind, the focus of this strategy is on ensuring that all the research themes develop in terms of overall maturity.

Table 4 opposite shows the themes and the transitions required for the human capacity, infrastructure, and networks and relationships dimensions of the model.

2 “Why Should the Taxpayer pay for research?”  
Graham Reid, 2014, University College London.



Table 4: Raising Maturity Levels across the 15 Themes

Transition	Capacity	Infrastructure	Networks & Relationships
Translational ↑ Collaborative	Renewable Energy	Socio Economics Planning & Governance Information & Spatial Technologies, Analytics and Modelling	Renewable Energy Socio Economics
Collaborative ↑ Established	Algal Cultivation Wild Fisheries Seaweeds Biodiscovery Advanced Technologies Subsea Resources Biodiversity, Ecosystems & Food-webs Ocean Observation and Seabed Mapping Ocean Literacy & Education Socio Economics Planning & Governance Information & Spatial Technologies, Analytics and Modelling	Algal Cultivation Seaweeds Biodiscovery Advanced Technologies Renewable Energy Biodiversity, Ecosystems & Food-webs Climate Change Ocean Observation and Seabed Mapping	Wild Fisheries Seaweeds Biodiscovery Advanced Technologies Biodiversity, Ecosystems & Food-webs Ocean Observation and Seabed Mapping Business Development Planning & Governance Information & Spatial Technologies, Analytics and Modelling
Established ↑ Defined	Security & Surveillance Climate Change	Shellfish Aquaculture Wild Fisheries Subsea Resources Security & Surveillance Ocean Literacy & Education Legal Business Development	Finfish Aquaculture Shellfish Aquaculture Subsea Resources Security & Surveillance Climate Change Ocean Literacy & Education Legal
Defined ↑ Ad Hoc	Finfish Aquaculture Shellfish Aquaculture Bioresource Processing Tourism & Leisure Transport & Logistics Pollution and Litter Legal Business Development Engineering	Finfish Aquaculture Bioresource Processing Tourism & Leisure Transport & Logistics Pollution and Litter Engineering	Algal Cultivation Bioresource Processing Tourism & Leisure Transport & Logistics Pollution and Litter Engineering

### Developing Human Capacity

A range of instruments are available to funders to develop human capacity, however, the selection of those instruments must be based on the existing level of research maturity. For each theme, consideration must be given to questions such as:

1. Are there suitable positions at the desired level of maturity for researchers to move into?
2. Where those positions do exist, are there suitably qualified applicants in the Irish system or can such candidates be identified from elsewhere and brought into the Irish system?
3. Is there a sufficient research base in place for meaningful research to take place?
4. Is there a defined societal or sectoral need for the research capacity?

Understanding these issues, and in order to ensure continued investment in marine research, requires the collection of baseline data on the operation of the Irish research system with regard to marine research. Such baseline data includes information on funding instruments provided by research funders (beyond that captured in this strategy), and an assessment of the scale of such funding across the various funding bodies (including identification of potential overlaps with the other societal benefit areas identified under Innovation 2020 such as food, environment etc.).

#### Action

2. Define instruments and metrics

#### Description

Quantify funding mechanisms and research spending.

#### I2020 Action

4.1 (b), 4.2

The Irish research system is ambitious in its vision for Ireland's research capability, and this is reflected by the instruments shown in Table 1. This ambition has in some instances resulted in a bias in research funding towards instruments that support the higher levels of maturity with respect to human capacity such as high profile researcher led centres. In a number of themes there is a need for increased focus on building an initial critical mass of research capability before such instruments can be considered.

#### Action

3. Build basic research capacity

#### Description

Identify requirements for basic capacity building (e.g. early stage researchers and PhD students).

#### I2020 Action

3.16

### Developing Infrastructure Capacity

A review of existing funding instruments carried out as part of the preparation of this strategy reveals that this is currently an underdeveloped dimension nationally. Since Cycle 5 of the Programme for Research in Third-Level Institutions<sup>3</sup> (PRTL I 2011-2015), competitive capital funding is limited to supports such as those offered by SFI and occasional focused calls such as the recent Enterprise Ireland Marine Incubator call. Such infrastructure is complemented by state managed/run national marine infrastructures.

Table 2 summarises the range of supports to marine researchers for infrastructure – this points to the need for an urgent, short term measure to support marine infrastructure in the Irish research system. Such a measure is specifically required to fund equipment and infrastructure of a scale beneath the thresholds covered by SFI infrastructure calls. In the medium to longer term, the introduction of a successor programme to the PRTL I as identified in Innovation 2020 will be critical.

3 PRTL I is a HEA administered research programme that offers third-level institutions an opportunity to build infrastructure, invest in capacity and capability, in line with institutional strategies.

<b>Action</b>
4. Research Equipment and Small Infrastructure Call
<b>Description</b>
Operate a call for marine-related equipment and small-scale infrastructure to complement calls by other funders such as SFI.
<b>I2020 Action</b>
3.16

From a marine perspective, physical platforms that enable research are often remote and operate in harsh conditions (e.g. National Research Vessels and oceanographic infrastructure). Their operation requires specialised technical expertise that often resides in publically funded bodies. A coordination forum that identifies platforms that support research capacity and enable knowledge sharing will avoid duplication of effort.

<b>Action</b>
5. Marine Infrastructure Providers Forum
<b>Description</b>
Establish a forum for operators of marine research infrastructure to enable researchers to access the marine environment and avoid duplication of effort.
<b>I2020 Action</b>
3.16(b)

As highlighted above, future investment in marine research infrastructure will be needed from sources such as a successor programme to the Programme for Third Level Research Infrastructure as identified under Innovation 2020. Such a programme will be competitive and will require an evidence base, if investments are to be made. In order to move towards such an evidence base, and in order to identify the gaps that exist from a national perspective, an inventory of marine-related research infrastructures should be carried out in support of the Innovation 2020 work plan.

<b>Action</b>
6. Inventory of Marine Research Infrastructures
<b>Description</b>
Carry out an inventory of marine research infrastructures with a view to carrying out a gap analysis for future investment.
<b>I2020 Action</b>
3.16(a)

The operation of such infrastructure in the marine environment can be expensive, and frequently involves the use of third party services for the operation and maintenance of platforms and equipment. Consequently, the access charges associated with the usage of such equipment can be a significant barrier to research. The Marine Institute has for a number of years operated a successful Research Vessel access programme, while Science Foundation Ireland provide support for access charges associated with equipment purchased under their programmes. Informed by the inventory of marine research equipment mentioned above, a national marine research access programme is recommended.

<b>Action</b>
7. National Marine Research Infrastructure Access Programme
<b>Description</b>
Scope a national marine research infrastructure access programme.
<b>I2020 Action</b>
3.16(b)

## Developing Networks & Relationships Capacity

A number of the instruments that can be utilised to develop capacity in the Networks and Relationships dimension overlap significantly with those that relate to the Human Capacity dimension. The overlap tends to occur at the higher levels of capacity development in the Research Capability Maturity Model as shown in Table 3. At lower levels the current research funding landscape shows an absence of suitable instruments.

In order to develop the research theme to a higher level of maturity, some of the available instruments will be more appropriate than others as was the case for developing human capacity. This is because some instruments either won't attract suitable applicants due to a lack of maturity, or because there is not a sufficient research base in place to capitalise on the investment that the instrument would represent.

### Action

8. Increase opportunities for SMEs to participate in Marine Research

### Description

Examine impediments and possible solutions to SME participation in marine research related activities including:

Promoting mechanisms for industry consortia formation,

Determining thresholds associated with financial contributions, both cash and in-kind, and

Introducing alternative models of financing.

### I2020 Action

2.4, 2.10

Many of the supports available nationally, and in particular those applicable at the higher levels of research maturity, require significant levels of industry participation in the form of co-funding. As marine-related industries tend to be regionally dispersed and characterised by a large number of SME and micro-SMEs, this

profile makes engagement with large-scale collaborative research centres often difficult. This represents a particular funding and financing challenge that needs to be addressed.

A further impediment to SME participation in marine-related research is an issue of awareness. The recent establishment of the Marine Development Team funded by the European Maritime and Fisheries Fund, together with associated initiatives such as the Enterprise Ireland Marine Industry Network, provide an opportunity to overcome this. These channels facilitate a mechanism for the research community and SME sector to interact.

### Action

9. Increase awareness of research opportunities amongst SMEs

### Description

Promote linkages between research performers and enterprise organisations to raise awareness of new technologies and processes in the marine sector.

### I2020 Action

2.12

A further mechanism for the SME sector to engage with research and innovation is through the use of Small Business Innovation Research (SBIR). The identification of marine-related challenges that can be addressed through SBIR should be pursued by all relevant research funders and enterprise agencies.

### Action

10. Small Business Innovation Research (SBIR)

### Description

Promote the usage of SBIR as a means to stimulate research and innovation.

### I2020 Action

4.5

# Thematic Coordination

Each of the analyses of the 15 research themes has identified research areas and an appropriate focus of funding. These are based both on the sectoral needs associated with the theme, and what is possible given the level or research maturity that can realistically be achieved.

It is clear that the maturity of marine research varies considerably across the 15 research themes. Raising the maturity for each theme can be achieved through use of appropriate instruments, while targeting research towards existing strategies can be achieved by funding agencies adhering to the suggested focus of funding for each theme. However, progress towards

the third goal of this strategy, namely achieving coherence in the approach to marine research by the various state actors, requires coordination and engagement between state bodies.

Engagement should take place at the thematic level taking account of the interdependencies and integrated nature of marine research. Relevant

funders should collaborate to achieve the demands of sectoral policies and plans. This should be aligned with the prioritisation articulated in national strategies such as Innovation 2020 and Enterprise 2025.

Action	Description	I2020 Action(s)
11. Thematic Research Coordination	Using existing structures or newly established working groups within the Marine Research Forum, coordinate, monitor and update as required the research priorities and focus of funding for each theme.	3.16, 4.1, 4.5

### The role of state research funding bodies

Government Departments and Agencies engaged in policy formulation and advice, and research funding have an important role in relation to the development of marine-related research in Ireland. Science Foundation Ireland, the Irish Research Council, the Environmental Protection Agency, the Geological Survey of Ireland, etc. have built up considerable expertise within one or more of the research themes identified by this strategy. These bodies have their own mandate to direct research relevant to policy advice, development of research excellence and sectoral development as appropriate.

The framework and associated analysis articulated in this strategy is designed to support all funders active in funding marine research to collectively and collaboratively advance national capacity and to ensure value for money.

The Marine Institute has a specific statutory remit in relation to marine research in Ireland. The Marine Institute Act 1991 states that the role of the Institute is: *"to undertake, to co-ordinate, to promote and to assist in marine research and development and to provide such services related to marine research and development, that in the opinion of the Institute will promote economic development and create employment and protect the marine environment"*.

In this context, a key role of the Marine Institute is to advise and support those agencies when they are operating in marine-related areas. The Institute does this through the provision of expert advice, guidance and sourcing national and international expertise where required.

Collectively, the agencies mentioned in this section have a role to play in the ongoing development of Ireland's marine research capability, including the monitoring and review of this strategy.

#### Action

12. Re-assess maturity capability for research themes

#### Description

Assess the maturity of research themes in terms of human capacity, infrastructure and networks and relationships prior to completion of the strategy period.

#### I2020 Action

1.1, 2.8, 2.11

### The role of the development agencies

Development agencies, including those associated with the Marine Development Team, such as Enterprise Ireland, the IDA, BIM, SEAI and Údarás na Gaeltachta, are of critical importance to achieving a fully translational research capacity in Ireland. The supports offered by these agencies, in relation to industry/research performer interactions, should be targeted on those research themes where the research base is sufficient to achieve economic development.

#### Action

13. Promote research for economic development

#### Description

Identify future research themes through industry foresight activities and horizon scanning.

Identify early stage applied research requirements and opportunities for co-funding.

#### I2020 Action

2.3

Where the research base is not sufficiently developed, but where potential new research topics or innovations can result in economic activity, the development agencies should partner with the research and policy advice bodies to direct activity in the lower maturity levels. Such collaboration should include industry foresight and horizon scanning activities together with research funding, in particular co-funding. Activities such as this will inform new research themes to be included in future marine research and innovation strategies.

# International Relationships

Ocean research is, by its very nature, internationally focused. Irish researchers have a strong and successful track record in participation in European research framework programmes. After three years of the current Horizon 2020 framework programme, Irish marine researchers have won a total of €24.9m across all pillars and instruments of H2020. This represents 6.5% of the total research funding awarded to Ireland under H2020 so far and is a marked increase from Framework Programme 7 awards for the same stage of the programme. In particular, in the Blue Growth (BG) topics in 2016, the total awarded is in excess of €1.6m, giving a total take of 2.2% from these BG calls. This shows Irish marine researchers performing well above their ‘juste retour’ and is also a confirmation of the success of capacity building measures implemented under the previous national marine research strategy – Sea Change.

## Participation in international science

Participation in international programmes and transboundary research promotes science excellence, provides greater access to information required to support and inform policy formulation, and ultimately improves the competitiveness of the Irish economy. Often such participation is built on the reputation of individual research teams, access to (and availability of) infrastructure and specialist knowledge. This is reflected

in the Research Capability Maturity Model used throughout this document, in particular in relation to research themes performing at the Established, Collaborative and Translational levels.

While this strategy has, in the main, considered only national research funding mechanisms, building towards higher levels of maturity requires careful consideration of the international instruments available. Irish research

fundors’ participation in ERA-nets or Joint Programming Initiative (JPI) co-funds can successfully introduce Irish research teams to international consortia. In order to maximise such opportunities it is important that research funders are aware of the opportunities to co-fund in such international settings. There are also similar opportunities linked to international science partnerships.

Action	Description	I2020 Action
14. Increase national collaboration across range of international research and science partnerships	<p>Maximise co-fund opportunities for Irish researchers (ERAnets, JPI Co-funds etc.).</p> <p>Highlight outputs and opportunities linked to international science partnerships and other fora.</p>	6.2, 6.6, 6.7

### The implications of BREXIT

Marine-related research themes have in the past featured strong linkages between Ireland and Northern Ireland, including research collaborations and access to equipment and infrastructure. Much of the research work undertaken has been in support of shared policy interests and transboundary issues.

The exit of the United Kingdom from the European Union poses particular challenges for the Irish research system including marine-related research. These challenges include the potential loss of existing research relationships, access to particular infrastructures and uncertainty surrounding programmes such as INTERREG. With challenges come opportunities, for instance the opportunity to take on leadership roles in international consortia.

There is a need to ensure continuation of these relationships, and to seek ways to mitigate the impacts of Brexit and pursue new cross border opportunities.

The use of national funds for researchers in Northern Ireland is not consistent amongst national research funders that operate calls of relevance to marine research themes. This should be considered and a consistent approach agreed.

#### Action

15. Review and share the range of international science partnerships and associations

#### Description

Explore all island H2020 opportunities to support Innovation 2020.

Explore Brexit opportunities and mitigation actions of mutual benefit to researchers in Ireland and Northern Ireland.

Review and ensure consistency of approach to marine research supports for researchers based in Northern Ireland.

#### I2020 Action

6.9

### The role of Smart Specialisation

A recent communication from the European Ministers responsible for the Integrated Maritime Policy on Blue Growth agreed to:

*“Encourage the inclusion of marine and maritime activities in the national and regional smart specialisation strategies and their development, taking account of relevant sea basin, sub-sea basin initiatives and macro-regional strategies as appropriate.”*

While Ireland’s smart-specialisation strategy is largely applied through the National Research Prioritisation Exercise, the inclusion of reference to marine and maritime (as one of the areas listed for social progress and the economy under Innovation 2020) will be key to the development of research infrastructures and capacity.

#### Action

16. Review the role of marine and maritime activities in Ireland’s approach to Smart Specialisation Strategy

#### Description

Establish marine and maritime links to the Innovation 2020 Social progress and Economy actions to ensure access to EU regional development funding for marine research and infrastructure.

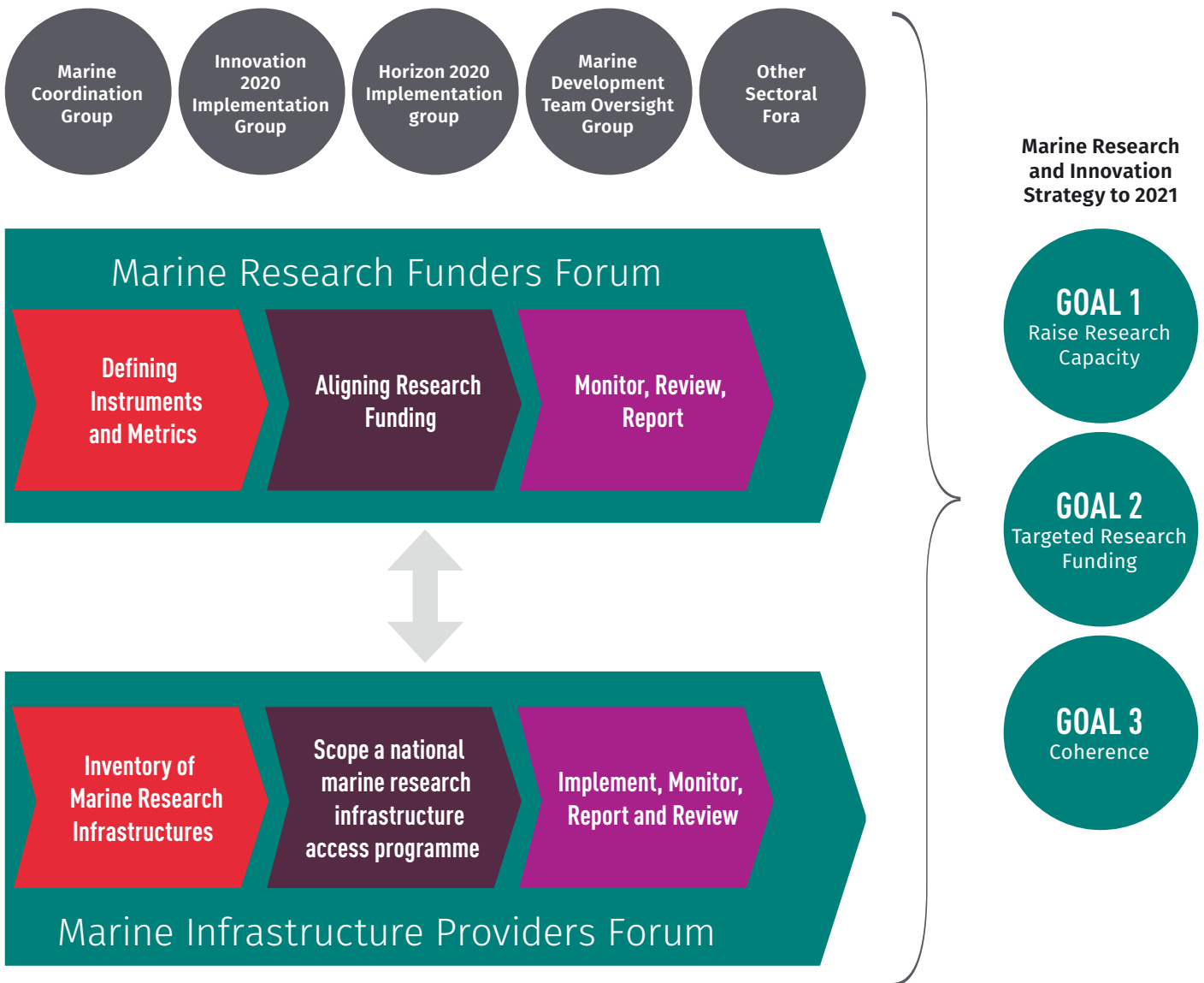
#### I2020 Action

6.5



# Implementing Structures

There are a number of existing cross government implementing structures in place to achieve a range of sectoral and research plans underway. The intention of the Marine Research Funders and Marine Infrastructure Providers Fora is not to duplicate the work of any exiting structures but to address gaps identified in this strategy and provide the required level of integration and oversight



# Summary of Key Implementing Actions

Actions	Description	Participants	Timeline	I2020 Action
1. Marine Research Funders Forum	Convene a research funders forum for organisations funding marine-related research themes.	MI, GSI, UnaG, BIM, FI, SFI/HEA, Teagasc, Met Éireann, EI, SEAI, IFI, NPWS, NWRA & SERA DAFM, DCCAE, HPCLG	2017	4.17
2. Define instruments and metrics	Quantify funding mechanisms and research spending.	Marine Research Funders Forum	2017	4.1 (b), 4.2
3. Build basic research capacity	Identify requirements for basic capacity building (e.g. early stage researchers and PhD students).	Marine Research Funders Forum	2017-2021	3.5
4. Research Equipment and Small Infrastructure Call	Operate a call for marine-related equipment and small-scale infrastructure to complement calls by other funders such as SFI.	Marine Institute	2017/2018	3.16
5. Marine Infrastructure Providers Forum	Establish a forum for operators of marine research infrastructure to enable researchers to access the marine environment and avoid duplication of effort.	MI, SFI, SEAI, GSI, CIL, BIM, EPA, Dept. of Defence, Relevant HEIs and RPOs.	2017-2021	3.16(b)
6. Inventory of Marine Research Infrastructures	Carry out an inventory of marine research infrastructures with a view to carrying out a gap analysis for future investment.	Marine Infrastructure Providers Forum	2017-2018	3.16(a)
7. National Marine Research Infrastructure Access Programme	Scope a national marine research infrastructure access programme.	Marine Infrastructure Providers Forum Marine Research Funders Forum	2018-2019	3.16(b)
8. Increase opportunities for SMEs to participate in Marine Research	Examine impediments and possible solutions to SME participation in marine research related activities including: Promoting mechanisms for industry consortia formation, Determining thresholds associated with financial contributions, both cash and in-kind, and Introducing alternative models of financing.	EI, SFI, DAFM, SEAI, MI/IMDO, BIM, UnaG and other agencies as appropriate	2017-2021	2.4, 2.10
9. Increase awareness of research opportunities amongst SMEs	Promote linkages between research performers and enterprise organisations to raise awareness of new technologies and processes in the marine sector.	Marine Development Team and associated agencies	2017-2021	2.12

Actions	Description	Participants	Timeline	I2020 Action
10. Small Business Innovation Research (SBIR)	Promote the usage of SBIR as a means to stimulate research and innovation.	Marine Research Funders Forum Marine Development Team and associated agencies.	2017-2021	4.5
11. Thematic Research Coordination	Using existing structures or newly established working groups within the Marine Research Forum, coordinate, monitor and update as required the research priorities and focus of funding for each theme.	Marine Research Funders Forum	2017-2021	3.16, 4.1, 4.5
12. Re-assess maturity capability for research themes	Assess the maturity of research themes in terms of human capacity, infrastructure and networks and relationships prior to completion of the strategy period.	Marine Research Funders Forum	2020	1.1, 2.8, 2.11
13. Promote research for economic development	Identify future research themes through industry foresight activities and horizon scanning. Identify early stage applied research requirements and opportunities for co-funding.	MI MDT and associated agencies Marine Research Forum	2017-2021	2.3
14. Increase national collaboration across range of international research and science partnerships	Maximise co-fund opportunities for Irish researchers (ERAnets, JPI Co-funds etc.). Highlight outputs and opportunities linked to international science partnerships and other fora.	Marine Research Funders Forum	2017-2021	6.2, 6.6, 6.7
15. Review and share the range of international science partnerships and associations	Explore all island H2020 opportunities to support Innovation 2020. Explore Brexit opportunities and mitigation actions of mutual benefit to researchers in Ireland and Northern Ireland. Review funding of research team based in Northern Ireland.	Marine Research Funders Forum	2017-2021	6.9
16. Review the role of marine and maritime activities in Ireland's approach to Smart Specialisation Strategy	Establish marine and maritime links to the Innovation 2020 Social progress and Economy actions to ensure access to EU regional development funding for marine research and infrastructure.	Marine Research Funders Forum DPER, DJEI, Regional Assemblies	2017-2021	6.5





# Research Capability Maturity Model

## Maturity

## Human Capacity

5

### Translational

There is evidence of a pipeline of research from basis investigation to commercial application or policy definition facilitated by dedicated national facilities.

- › Industry based researchers involved in Product Development Lifecycles.
- › Researchers participating in legislatively based, or ministerial appointed, fora that inform legislation or regulation.

4

### Collaborative

National level research facilities exist with international collaboration with internationally recognised research performers.

- › International Research Awards, e.g. ERC Research Awards.
- › International Travel Awards, e.g. Fulbright.
- › International Research Contracts e.g. EU Tender Awards.
- › Regular development or refinement of methods, techniques or processes that inform regulation.

3

### Established

Dedicated research facilities exist and there is evidence of collaboration nationally and internationally, with industry participation.

- › Established Principal Investigator Position(s).
- › PI Led Research Teams with Postdoctoral Researchers.

2

### Defined

Communities of interest exist with some access to facilities and active research projects.

- › Multiple Project Based PI Appointments.
- › Active PhD Level Research Projects.
- › Undergraduate courses with established lecturers.

1

### Ad-hoc

Research is based on individual research interests with no institutional support or facilities.

- › No dedicated facilities, general purpose equipment etc.
- › No dedicated training or education associated with the field.

# Dimensions

## Infrastructures

- › Nationally funded research centres.
- › Postdoctoral Training.
- › EU “Best in class” research infrastructures.
- › National Test & Demonstration Facilities, including end-user population for real-world feedback.

- › Nationally available equipment or platforms (e.g. equipment pools).
- › Postgraduate training.
- › Participation in EU infrastructure networks.
- › National Test and Demonstration facilities.
- › Postdoctoral training.

- › Purpose built lab space/purpose bought equipment.
- › Dedicated data infrastructures or repositories.
- › Postgraduate teaching modules and/or courses.

- › Defined undergraduate training.
- › “Allocated” general purpose lab space or equipment, evidence of institutional commitment through capital spending.

- › No dedicated facilities or general purpose equipment etc.
- › No evidence of commitment through capital spending.

## Networks & Relationships

- › Networks of interest featuring high levels of industry or policy-making participation.
- › IP frameworks available.
- › Consistent leadership roles in international standard setting forums.
- › Consistent leadership roles in international inter-governmental mandated scientific organisations.

- › Inter-institutional research cluster/centres.
- › Industry collaboration in research including industry funding.
- › Industry participation in research theme definition.
- › Funding from policy-making organisations.

- › Multiple teams concurrently participating in Framework/H2020 projects.
- › Industry or sectoral policy-maker led research themes.
- › Regular national conferences/workshops with some international participation.

- › National Workshops.
- › Inclusion in Framework/H2020 bids.
- › Recognised community of interest.

- › No nationally organised/hosted workshops.
- › No associations, networks of interest.
- › Collaboration is based entirely on one-to-one or personal relationships.



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