

# Towards a Marine Research & Innovation Strategy 2021

## CONSULTATION DOCUMENT

The Marine Institute, as Ireland's national marine research and development agency, has over the past 24 months been engaged in a process of reviewing marine research performance in Ireland. This has been with a view to preparing a new national marine research & innovation strategy as called for under Harnessing Our Ocean Wealth.

How to get involved - **Complete the survey**

Ten questions have been designed to capture your views. These questions are provided on page 1 of this document.

Your responses can be submitted via an online survey available via the Marine Institute's website **[www.marine.ie](http://www.marine.ie)**

# CONTENTS

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CONSULTATION QUESTIONS .....	1
IRELAND, SCIENCE AND THE SEA FOREWORD BY THE CEO OF THE MARINE INSTITUTE .....	2
INTRODUCTION.....	4
Research Themes.....	4
Research Drivers .....	6
Research Maturity Capability Assessment .....	6
Focus of funding .....	9
FUNDING INSTRUMENTS .....	10
Developing Human Capacity .....	11
Developing Infrastructure Capacity.....	17
Developing Networks & Relationships Capacity.....	25
STATEMENT OF STRATEGY .....	33
The role of research funders.....	33
The role of the development agencies.....	34
The role of the Marine Institute .....	34

ANALYSIS OF RESEARCH THEMES .....	35
A THRIVING MARITIME ECONOMY .....	36
Bioresources – General.....	37
Bioresources – Aquaculture & Biomass Production .....	39
Bioresources – Wild Resources .....	41
Bioresources – Processing for Food and Other Use .....	43
Bioresources – Value Added Products.....	45
Advanced Technologies.....	47
Subsea Resources .....	49
Renewable Energy .....	50
Tourism.....	53
Transport.....	55
Security & Surveillance .....	57
HEALTHY MARINE ECOSYSTEMS .....	59
Biodiversity, Ecosystems & Food-webs.....	60
Litter .....	63
Climate Change .....	65
Ocean Observation .....	67
ENGAGEMENT WITH THE SEA .....	70
Ocean Literacy & Education .....	72
Integrated Policy and Governance.....	74
Information & Spatial Technologies, Analytics and Modelling .....	79
Engineering .....	81

# CONSULTATION QUESTIONS

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## Seeking Your Views

### Towards a Marine Research & Innovation Strategy 2021

#### A. General

- Q1. The strategy identifies 15 themes that are based on a review of national and international strategies. Do these appropriately capture the full range of research drivers, and if not what are the omissions?
- Q2. Do the dimensions of Human Capacity, Infrastructure and Networks & Relationships appropriately capture the kinds of supports required by a Research and Innovation (R&I) system?
- Q3. Are the five levels an appropriate classification of maturity? If not, what changes would you propose and why?
- Q4. The document outlines approaches to raising the maturity of the R&I systems associated with each theme. Are the instruments described sufficient to achieve this? What other instruments might be required?
- Q5. The Statement of Strategy section outlines certain roles and responsibilities of certain departments and agencies. Are these adequate and accurate? If not please provide details

#### B. Theme Specific

- Q6. Each theme section outlines key policy drivers and sectoral plans relevant to R&I for the theme. Is this complete and if not please cite examples
- Q7. There is an assessment of each theme's maturity. Is this reflective of the status of the theme? If not please provide evidence, with reference to the indicators outlined in the model (see page 8 of the draft strategy)
- Q8. Research areas are summarised based on the requirements of the key policies and sectoral plans. Are there omissions? If so please outline what these are with reference to policy documents
- Q9. Will the focus of funding outlined achieve the research requirements of the theme and achieve impact with reference to research maturity and capability?
- Q10. Have you any other comments?

# IRELAND, SCIENCE AND THE SEA

## FOREWORD BY THE CEO OF THE MARINE INSTITUTE

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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.

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 best 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 focussed 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 Development Task Force. By encouraging interaction between disciplines, the marine sector can benefit from Ireland's wider research talent pool and research infrastructure.

## INTRODUCTION

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This document sets out Ireland's Marine Research and Innovation Strategy for the period 2016 - 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

As the agency charged with the preparation of this National Marine Research and Innovation Strategy, the Marine Institute has endeavoured to reflect national goals from a broad range of policy areas that have a marine component. 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 themes are cross sectoral in nature, including such areas as transport, energy, food and biodiversity. The themes 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.

	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 - Value Added Products	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Advanced Technologies</b>	✓		✓	✓	✓	✓	✓	✓	✓
<b>Subsea Resources</b>	✓		✓	✓	✓	✓			✓
<b>Renewable Energy</b>	✓			✓	✓	✓	✓	✓	✓
<b>Tourism</b>	✓			✓	✓	✓			✓
<b>Transport</b>	✓			✓	✓	✓			✓
<b>Security &amp; Surveillance</b>	✓	✓		✓	✓	✓	✓	✓	✓
<b>HEALTHY MARINE ECOSYSTEMS</b>									
<b>Biodiversity, Ecosystems &amp; Food Webs</b>	✓	✓	✓	✓	✓		✓		
<b>Litter</b>	✓	✓		✓	✓				
<b>Climate Change</b>	✓	✓	✓	✓	✓		✓		
<b>Ocean Observation</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>	✓			✓	✓	✓	✓	✓	✓

Figure 1: Cross-Cutting National and International Policy Drivers



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.



*Figure 2 - Elements of thematic review*

## Research Drivers

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

## 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.

		Dimensions		
		Human Capacity	Infrastructures	Networks & Relationships
Maturity	“Translational”	There is evidence of a pipeline of research from basic investigation to commercial application or policy definition facilitated by dedicated national facilities		
	“Collaborative”	National level research facilities exist with international collaboration with internationally recognised research performers		
	“Established”	Dedicated research facilities exist & there is evidence of collaboration nationally & internationally, with industry or policy maker participation		
	“Defined”	Communities of interest exist with some access to facilities and active research projects		
	“Ad-hoc”	Research is based on individual research interests with no institutional support or facilities		

Figure 3 - Research Capability Maturity Model

Figure 3 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 4).

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.

DIMENSIONS				
MATURITY		Human Capacity	Infrastructures	Networks & Relationships
	<p><b>Level 5: Translational</b> There is evidence of a pipeline of research from basis investigation to commercial application or policy definition facilitated by dedicated national facilities</p>	<p>Industry based researchers involved in Product Development Lifecycles</p> <p>Researchers participating in legislatively based, or ministerial appointed, fora that inform legislation or regulation</p>	<p>Nationally funded research centres</p> <p>Postdoctoral Training</p> <p>EU "Best in class" research infrastructures</p> <p>National Test &amp; Demonstration Facilities, including end-user population for real-world feedback</p>	<p>Networks of interest featuring high levels of industry or policy-making participation</p> <p>IP frameworks available</p> <p>Consistent leadership roles in international standard setting forums</p> <p>Consistent leadership roles in international inter-governmental mandated scientific organisations.</p>
	<p><b>Level 4: Collaborative</b> National level research facilities exist with international collaboration with internationally recognised research performers</p>	<p>International Research Awards, e.g. ERC Research Awards</p> <p>International Travel Awards, e.g. Fulbright</p> <p>International Research Contracts e.g. EU Tender Awards</p> <p>Regular development or refinement of methods, techniques or processes that inform regulation</p>	<p>Nationally available equipment of platforms (e.g. equipment pools)</p> <p>Postgraduate training</p> <p>Participation in EU infrastructure networks</p> <p>National Test and Demonstration facilities</p> <p>Postdoctoral training</p>	<p>Inter-institutional research cluster/centres</p> <p>Industry collaboration in research including industry funding</p> <p>Industry participation in research theme definition</p> <p>Funding from policy-making organisations</p>
	<p><b>Level 3: Established</b> Dedicated research facilities exist and there is evidence of collaboration nationally and internationally, with industry participation</p>	<p>Established Principal Investigator Position(s)</p> <p>PI Led Research Teams with Postdoctoral Researchers</p>	<p>Purpose build lab space/purpose bought equipment</p> <p>Dedicated data infrastructures or repositories</p> <p>Postgraduate teaching modules and/or courses</p>	<p>Multiple teams concurrently participating in Framework/H2020 projects</p> <p>Industry or sectoral policy-maker led research themes</p> <p>Regular national conferences/workshops with some international participation</p>
	<p><b>Level 2: Defined</b> Communities of interest exist with some access to facilities and active research projects</p>	<p>Multiple Project Based PI Appointments</p> <p>Active PhD Level Research Projects</p> <p>Undergraduate courses with established lecturers</p>	<p>Defined undergraduate training</p> <p>"Allocated" general purpose lab space or equipment, evidence of institutional commitment through capital spending</p>	<p>National Workshops</p> <p>Inclusion in Framework/H2020 ids</p> <p>Recognised community of interest</p>
	<p><b>Level 1: Ad-Hoc</b> Research is based on individual research interests with no institutional support or facilities</p>	<p>No dedicated facilities, general purpose equipment etc.</p> <p>No dedicated training or education associated with the field</p>	<p>No dedicated facilities or general purpose equipment etc.</p> <p>No evidence of commitment through capital spending</p>	<p>No nationally organised/hosted workshops</p> <p>No associations, networks of interest</p> <p>Collaboration is based entirely on one-to-one or personal relationships</p>

Figure 4 - Research Capability Maturity Model

## Focus of Funding

Each review of the 15 research themes identifies prioritised research areas and an appropriate focus of funding. This is based both on the sectoral needs identified in the review, and what is possible given the level or research maturity that can realistically be achieved.

More generally, a separate analysis of national research funding instruments available to marine researchers is also provided in the strategy. This analysis identifies those themes at similar levels of research capability, and identifies either existing instruments that can be utilised to advance the themes' maturity levels, or gaps where new instruments are required.

The assessments carried out as part of the preparation of this strategy reveal that the maturity of marine research varies considerably across the 15 research themes. This strategy adopts a twin track approach to developing marine research in Ireland.

- To be **directed by the demands of the relevant policy and sectoral documents** for that research theme in deciding what research topics are to be funded.
- To target this funding such that it **increases the overall research maturity** of the research theme, in particular by focusing on the dimension or dimensions that are the least mature.

This strategy makes no judgements of the relative importance of any one theme over another. However, it is a well-established principle of public funding for research that investments made in research spending yield benefits for society, both in terms of development of enterprise and informing public policy<sup>1</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. Given the variety of capabilities identified, it is necessary to identify the appropriate types of funding that are appropriate for each research theme. 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.

This approach is of course tempered by the need for a country such as Ireland with finite resources to prioritise investments. This achieves both by relying on the demands of relevant policy sectoral documents as set out above, and recognising the prioritisation articulated in national strategies such as **Innovation2020** and **Enterprise2025**.

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<sup>1</sup> "Why Should the Taxpayer pay for research?", Graham Reid, 2014, University College London.

## FUNDING INSTRUMENTS

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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. An analysis of these instruments 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 proliferation 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. Conversely many supports that are available are suitable for well-established research themes; however, often the research base in Ireland is 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.

Taking these insights into account, careful consideration of what instruments 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 is used as a frame of reference (see Page 8).

A range of agencies are actively engaged in providing the supports required. Some gap areas exist; while in others focus on the marine dimensions of a particular research theme is required through advice or co-funding. The Marine Institute has a particular role in this regard and this is discussed further in the statement of strategy chapter.

## Developing Human Capacity

A range of instruments are available to funders to develop human capacity in the various research themes examined. In order to develop the research theme to a higher level of maturity, some instruments will be more appropriate than others. This is because some instruments either won't attract suitable applicants because of 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.

A summary of the types of instruments that are appropriate at each level, together with existing examples and indicative cost ranges is provided below in Table 1 - Instruments for Capacity Development. Note that in some cases the same instrument can be applied to more than one transition.

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
		SFI "Industry Fellowship" 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
Defined ↑ Ad Hoc	Undergrad training prog 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
		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	
Ad Hoc ↑ Unassessed	Desk Studies and Research Masters	DAFM "Small Project"	≤ €100,000
	Awards to promote awareness and knowledge	Marine Institute Media Awards	≤ €100,000
	PhD Scholarships	Marine Institute "Cullen" Awards	≤ €100,000
	Support for undergraduate training programmes	SMART Programme	≤ €300,000

The following pages summarise the capacity development required in each of the research themes.

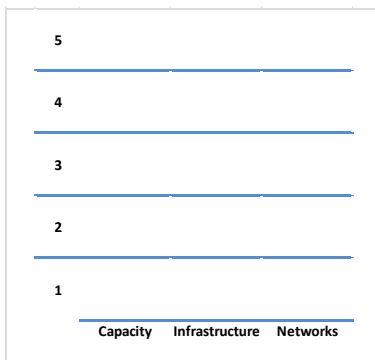
### **Moving Human Capacity from “Unassessed” to “Ad-hoc”**

There are relatively few circumstances where support for the development of Human Capacity is required to advance from “Unassessed” (i.e. not registering on the model) to “Ad-hoc”. This situation could arise however in the future where new fields emerge that require a rapid response to build a research base. The only example where this currently arises is in relation to marine engineering, where intervention is required to harness the extensive capabilities in this area for marine application.

Suitable instruments in this regard include desk-studies at Master’s Degree or Doctorate Level, Scholarships and awards to HEIs to promote teaching in the area.

#### **Requirement:**

Only one area, Engineering, is currently identified as requiring intervention of this type (see page 81).



*Engineering*

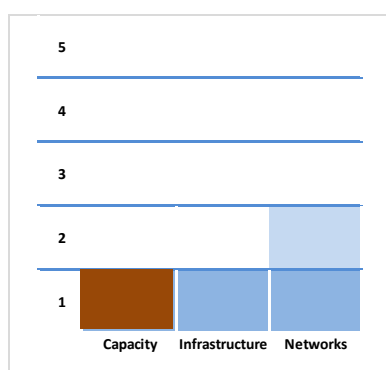
## Moving Human Capacity from “Ad-hoc” to “Defined”

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.

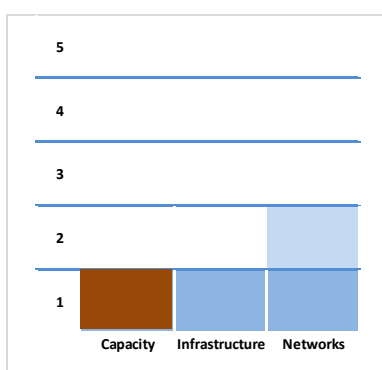
Suitable instruments include support to HEIs to promote teaching in the area, PhD scholarships, project-based Principal Investigator awards, and awards to high potential early career researchers.

### Requirement

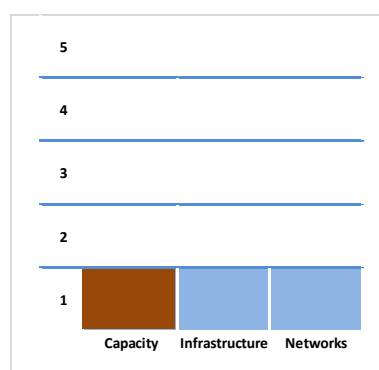
The review of the research themes has shown a requirement for such instruments in the bio-resources (aquaculture and processing), tourism, transport, litter and policy support themes (legal and business development).



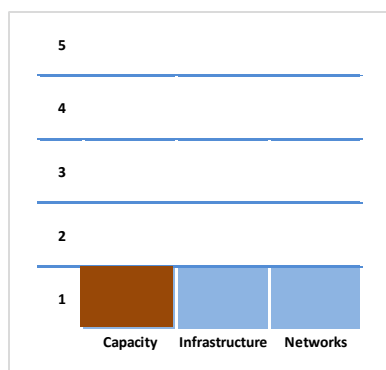
*Finfish Aquaculture*



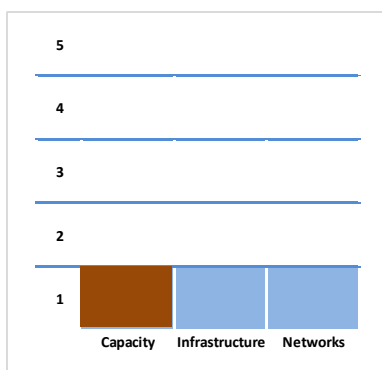
*Shellfish Aquaculture*



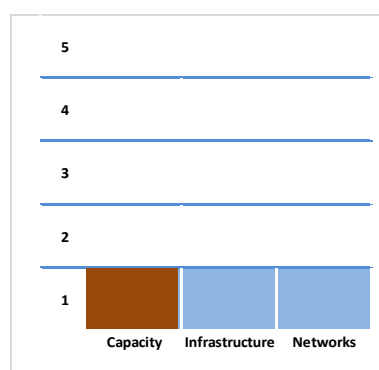
*Bioresource Processing*



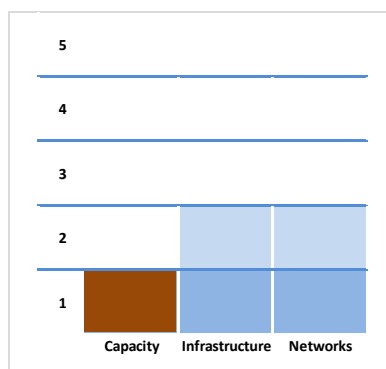
*Tourism*



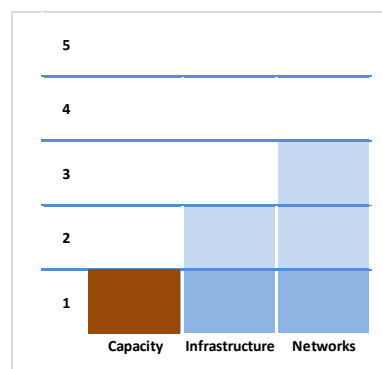
*Transport*



*Litter*



*Legal*



*Business Development*



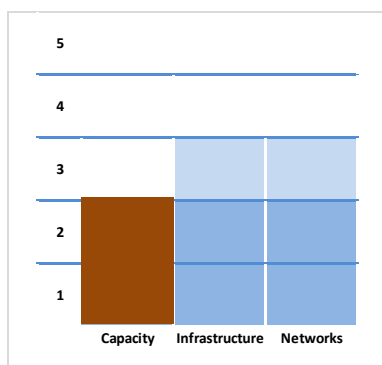
## Moving Human Capacity from “Defined” to “Established”

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.

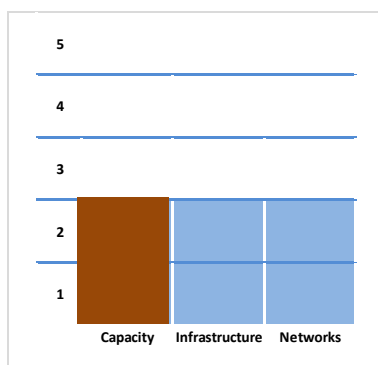
An example of such a mechanism is the SFI Investigators Programme. This programme indirectly incentivises HEIs to establish Principal Investigators which can then be leveraged to receive funding for large research teams. At this level, co-funding by sector specific agencies can promote a particular focus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

### Requirement

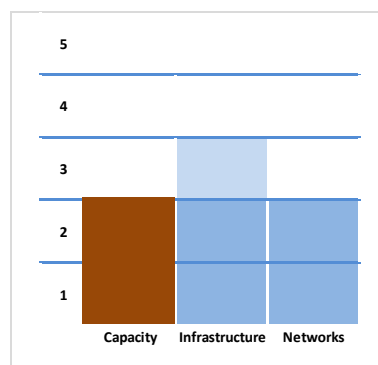
The review has shown a requirement for such instruments to be applied in the areas of renewable ocean energy, maritime security and surveillance, climate change and ocean literacy.



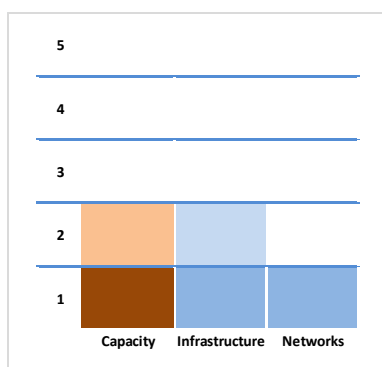
*Renewable Energy*



*Security & Surveillance*



*Climate Change*



*Ocean Literacy & Education*

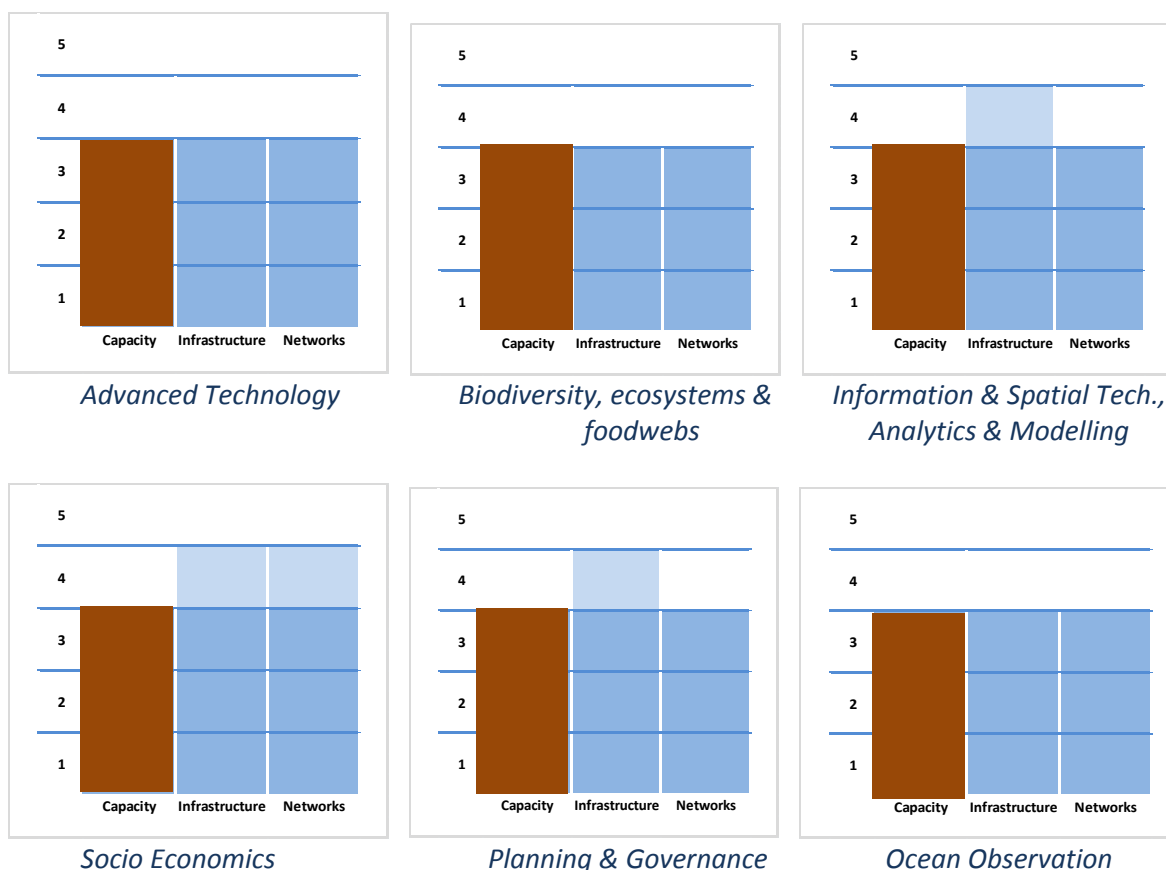
## Moving Human Capacity from “Established” to “Collaborative”

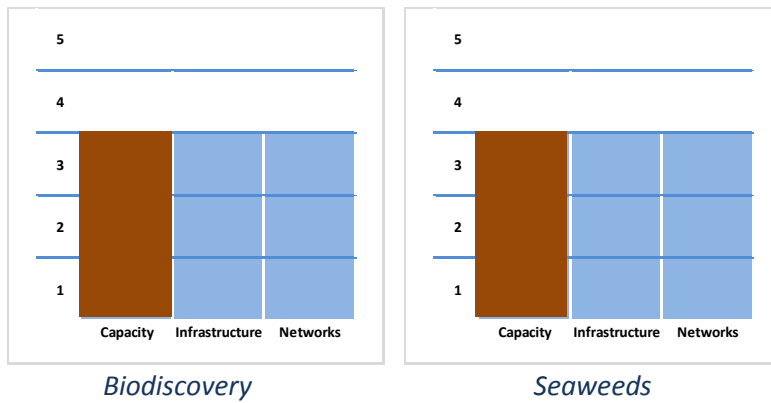
At the “Collaborative” level, the research base in a particular theme should be capable of operating in an international arena, which implies numbers of senior researchers who are recognised as providing some degree of leadership in their field.

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.

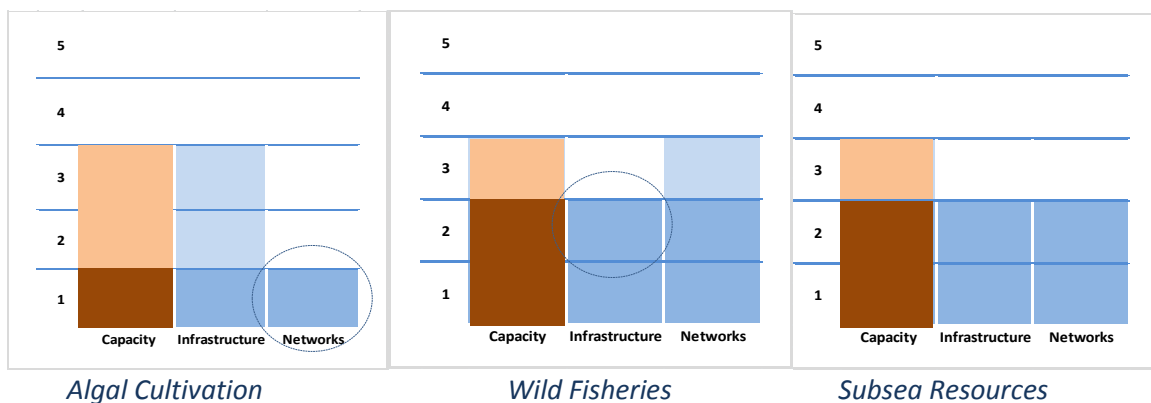
### Requirement

The analysis identifies a significant number of research themes that are at the “Established” level of maturity in terms of human capacity that require supports to move to “Collaborative”.





In the case of the themes below (Algal Cultivation, Wild Fisheries and Subsea Resources), while the next capacity step in Human Capacity building is to “Collaborative”, the immediate focus of investment is on other dimensions such as Infrastructure or Networks & Relationships.



### **Moving Human Capacity from “Collaborative” to “Translational”**

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.

#### **Requirement**

At the moment, there is no research theme showing a requirement for instruments to support the development of capacity from the “Collaborative” level to “Translational”. However, several themes that are listed in the “Established” to “Collaborative” transition above would benefit from supports of this kind. This is particularly the case where the field is at the “Collaborative” level in terms of the Infrastructure and Networks & Relationships dimensions, e.g. Socio Economics, Planning and Governance and Information Technology.

## Developing Infrastructure Capacity

The term Infrastructure as used in this strategy relates to pre-requisite resources such as the underlying facilities, and equipment and platforms that researchers require to carry out their work. This broad definition includes the provision of and access to physical assets, data assets, and suitably qualified people to support their operation.

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 the close of Cycle 5 of the Programme for Research in Third-Level Institutions<sup>2</sup> (2011-2015), 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. From a marine perspective, where 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 resides in national agencies.

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<sup>2</sup> PRTL 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.

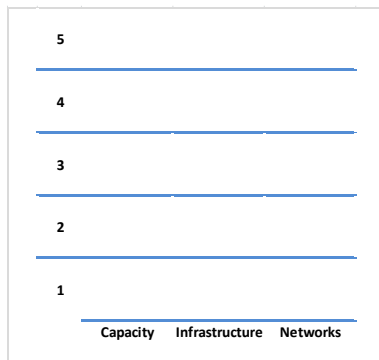
Table 2 - Instruments for Development of and Access to Infrastructure

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	
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	
Established ↑ Defined	Supports for the acquisition of specialist equipment		€70,000 to €500,000
	Funding for purpose built laboratory space		≤ €3m
	Supports for the acquisition of specialist equipment		€50,000 to €500,000
Defined ↑ Ad Hoc and Ad Hoc ↑ Unassessed	Support for the development/expansion of Undergraduate and taught Post Graduate training programmes,		≤ €150,000
	Co-funding of HEI/RPO equipment acquisition		≤ €50,000

## Moving Infrastructure Capacity from “Unassessed” to “Ad-hoc”

### Requirement

Only one area, Engineering, is currently identified as requiring intervention of this type, reflecting the general lack of marine focus in the engineering field nationally. A key intervention in this regard is to support existing under-graduate engineering courses to add marine-related electives or modules to their programmes. In addition, the establishment of post graduate training programmes to allow engineering graduates pursue a marine career is desirable.



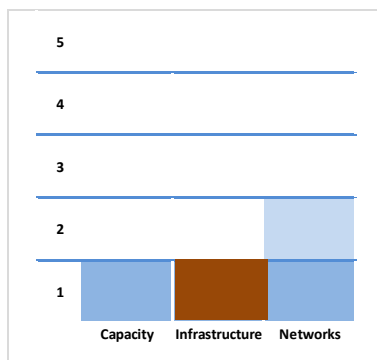
*Engineering*

## Moving Infrastructure Capacity from “Ad-hoc” to “Defined”

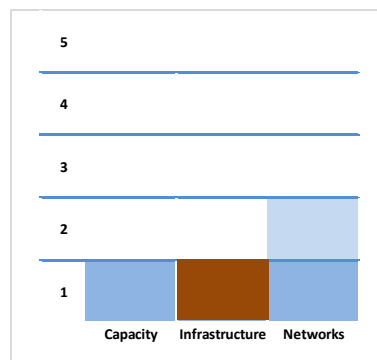
A number of research themes register low across all the dimensions of Human Capacity, Infrastructure and Network & Relationships. These themes also require investment in terms of teaching capacity in order to develop a means to provide future human capacity, coupled with modest equipment purchases and facilities. In a few instances, there are required infrastructures in place; however, these are often 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.

### Requirement

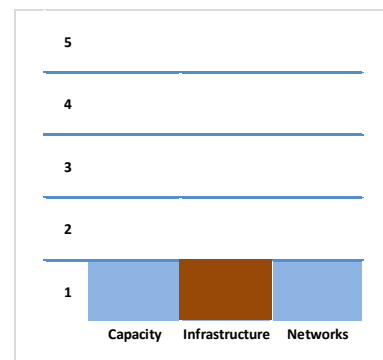
Research themes that would benefit from such interventions span across the bioresources theme (aquaculture and processing), tourism, transport and litter.



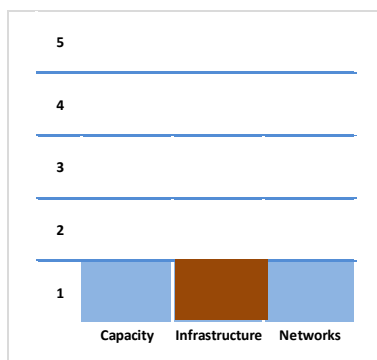
*Finfish Aquaculture*



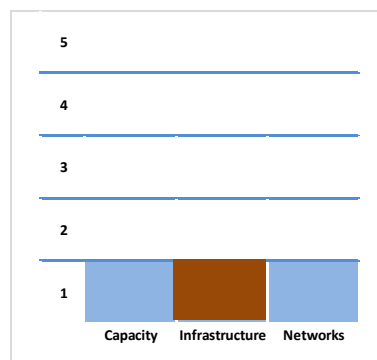
*Shellfish Aquaculture*



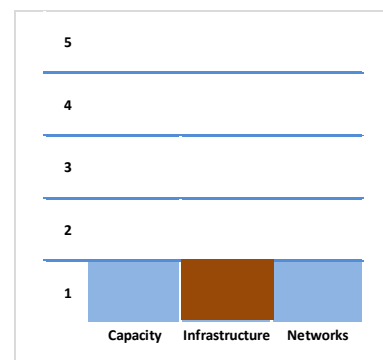
*Bioresource Processing*



*Tourism*



*Transport*



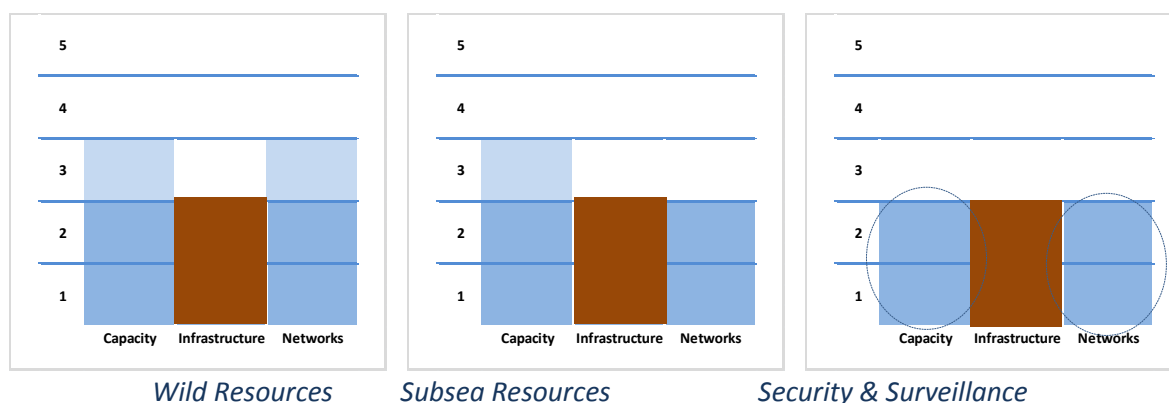
*Litter*

## Moving Infrastructure Capacity from “Defined” to “Established”

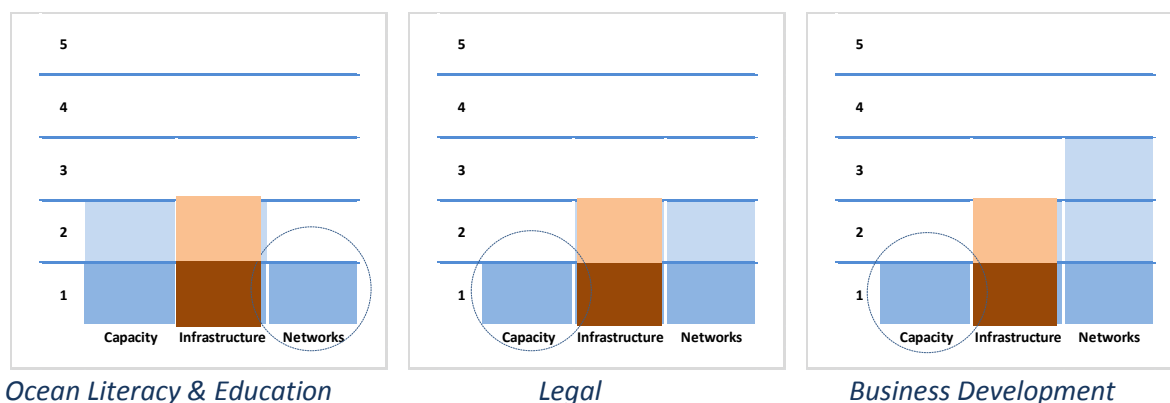
In this transition, research themes see the emergence of centres of excellence and levels of inter-institutional collaboration. In particular, facilities, equipment, and knowledge-support platforms are made available to advance the Human Capacity and Networks & Relationships levels.

### Requirement

There are two research themes, Wild Resources and Subsea Resources, where state investment related to infrastructure will have an impact on the overall maturity of the theme. The Security and Surveillance theme is also in a position to take advantage of such investment; however, this needs to be coupled with parallel investments in Human Capacity and Networks & Relationships.



A number of other themes are in a position to progress to the “Established” level from an Infrastructure perspective but need investment in building Human Capacity and Networks & Relationships for such a progression to be realised. These include the Ocean Literacy & Education, Legal and Business Development research themes.





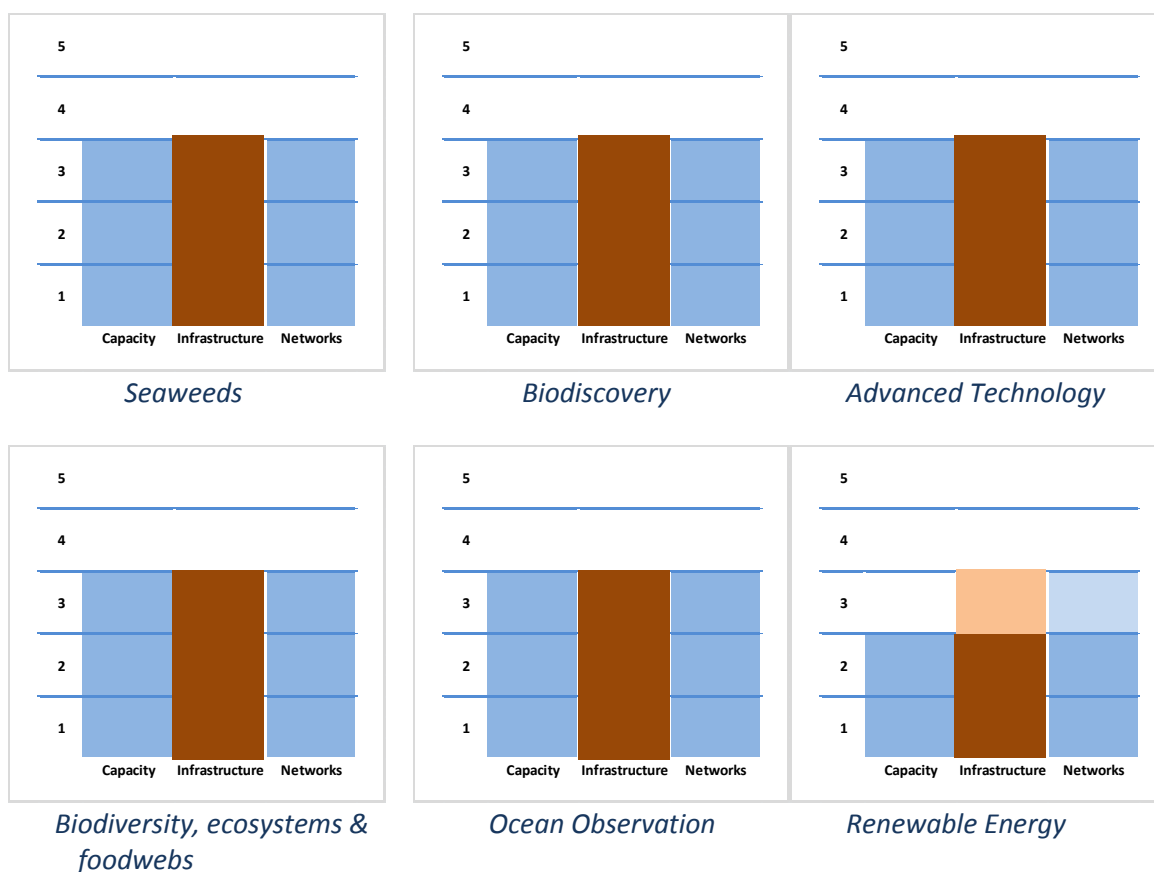
## Moving Infrastructure Capacity from “Established” to “Collaborative”

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.

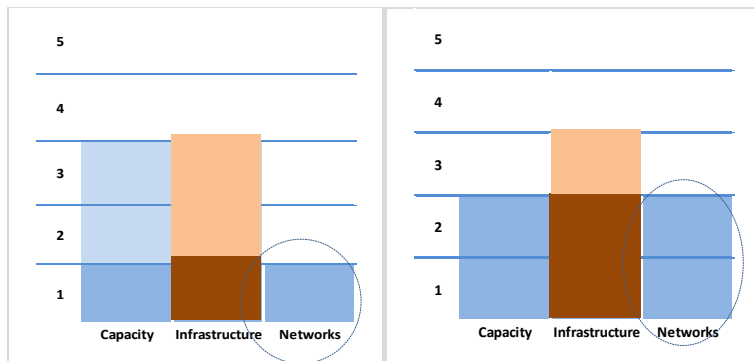
At this level, research excellence is only one consideration and strategic imperatives, such as the requirement for policy advice, need to be considered.

### Requirement

There are a number of areas where investment in infrastructure could support an overall move to the “Collaborative” level if coupled with supports in Human Capacity and Networks & Relationships. These themes include Seaweeds, Biodiscovery, Advanced Technology, Biodiversity, Ecosystems & Food-Webs, Ocean Observation and Renewable Energy.



Although the Algal Cultivation and Climate Change research themes are close to the “Established” level from an Infrastructure perspective, a more pressing need for these themes is in the area of Networks & Relationships.



*Algal Cultivation*

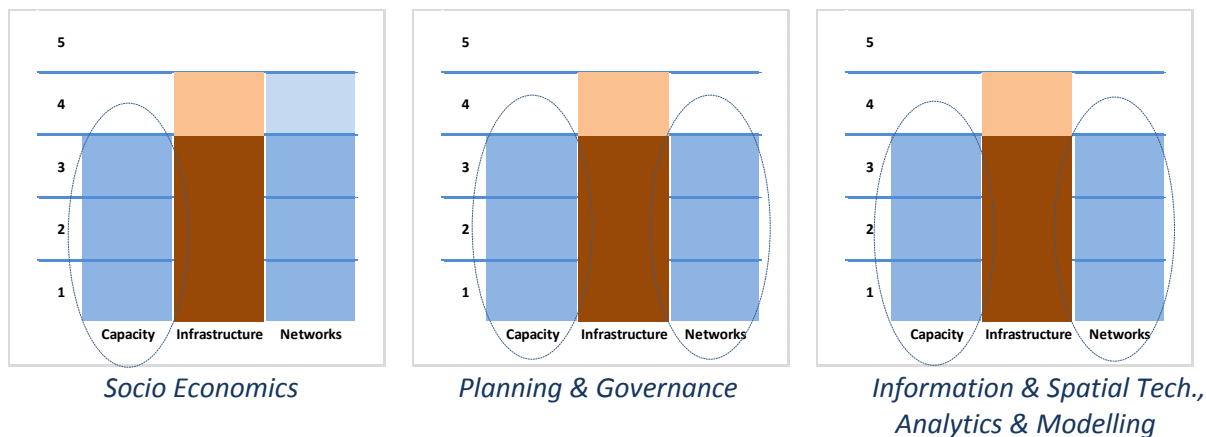
*Climate Change*

## Moving Infrastructure Capacity from “Collaborative” to “Translational”

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.

### Requirement

The analysis of the research themes indicates a number of research themes with a high-level of infrastructure capacity. In this case the focus of the funding is not to move the infrastructure capacity to “translational” but to focus efforts on requirements from a Human Capacity and Networks & Relationships perspective as outlined in the diagram below.



## 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. This reflects the fact that very often research teams must collaborate with others to develop their skills. However, this overlap tends to occur at the higher levels of capacity development in the Research Capability Maturity Model. At lower levels the current research funding landscape shows an absence of suitable instruments.

As previously stated in this section 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-SME enterprises, this profile makes engagement with large-scale collaborative research centres difficult. This represents a particular funding challenge that needs to be addressed.

A range of networking instruments are available across the various research themes. In order to develop the research theme to a higher level of maturity, some instruments will be more appropriate than others. 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.

A summary of the types of instrument that are appropriate at each level is provided below in Table 3, together with existing examples and indicative cost ranges. Note that in some cases the same instrument can be applied to more than one transition.

Table 3 - Instruments for Developing Networks & Relationships

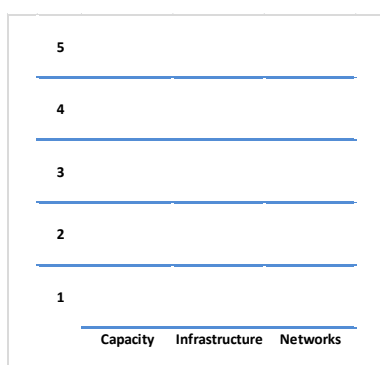
Transition	Description of types of suitable supports	Existing Examples	Typical Cost over lifetime of award
Translational ↑ Collaborative	Awards to promote leadership roles in inter-governmentally mandated scientific organisations		≤ €75,000
	Awards to promote leadership roles in industry standards		≤ 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	€80,000 to €350,000
EI Innovation Hub Awards		≤ €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	≤ €1m to €5m
	EI Technology Centres	≤ €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
Ad Hoc ↑ Unassessed	Awards that encourage contacts between research Institutions	DAFM “Desk Study”	≤ €200,000

## Moving Networks Capacity from “Unassessed” to “Ad-hoc”

As is the case with other dimensions of the Research Capability Maturity Model, the occasions where a research theme cannot be measured on the model are rare. In the case of the Networks & Relationships model, 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.

### Requirement

Only one area, Engineering, is currently identified as requiring intervention of this type.



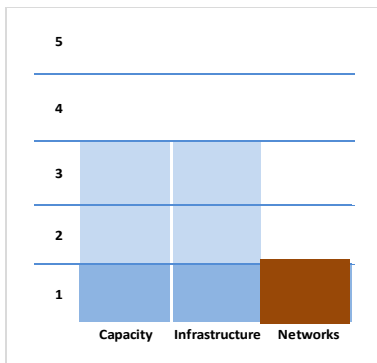
*Engineering*

## Moving Networks & Relationships Capacity from “Ad-hoc” to “Defined”

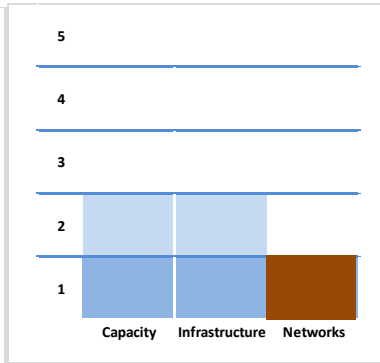
The key feature of the “Defined” level from a Networks & Relationships perspective is the existence of identifiable, active, communities of interest. Supports that can encourage such communities include medium-scale awards that bring research performing organisations together to collaboratively address 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.

### Requirement

The analysis shows that in the case of Algal Cultivation and Ocean Literacy & Education research themes, strengthening capacity in Networks & Relationships can have a significant impact on the overall research maturity level.

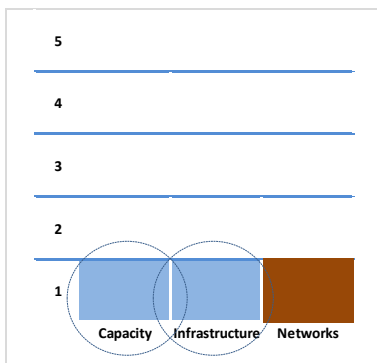


*Algal Cultivation*

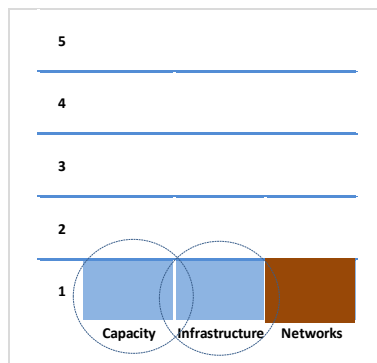


*Ocean Literacy & Education*

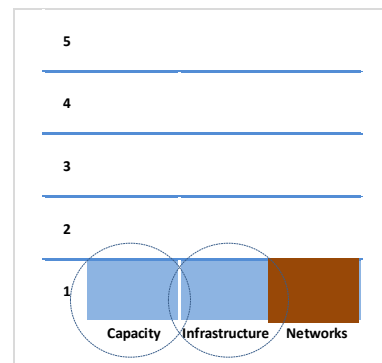
In a number of other instances, there are research themes where Networks & Relationships represent just one of the three research maturity dimensions that require support. These include Tourism, Transport, Litter and, Bioresource Processing.



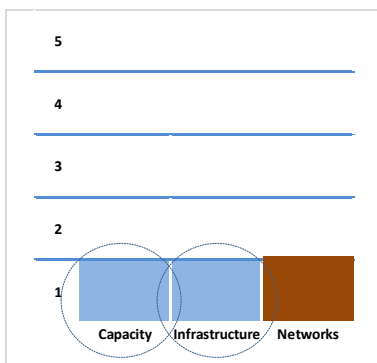
*Tourism*



*Transport*



*Litter*



*Bioresource Processing*

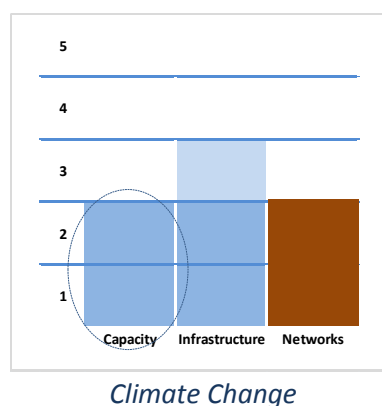
## Moving Networks & Relationships Capacity from “Defined” to “Established”

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.

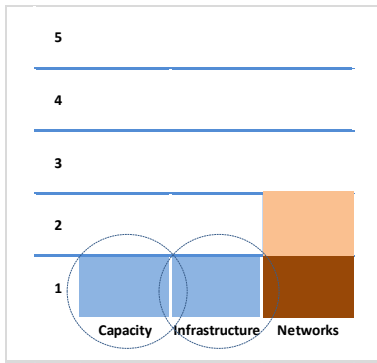
### Requirement

There is little evidence that supporting the Networks & Relationships dimension alone will significantly impact on that themes overall research maturity level. The exception to this is in the case of the Climate Change theme. Given the commonality of supports with the Human Capacity dimension, a significant improvement in national capacity could be achieved through focusing effort and investment on collaboration and coordination activities.

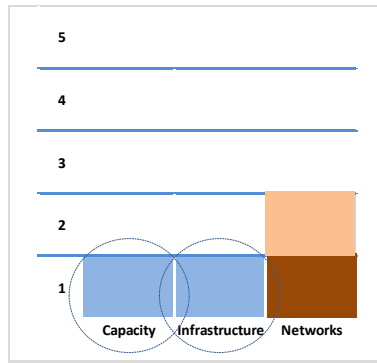


The analysis also shows a need for support in building Relationships & Networks across the Aquaculture, Sub-Sea Resources, Security & Surveillance and Legal research themes; however, as referred to above, additional supports across other dimensions are required to raise the overall maturity level. For example, in the Aquaculture theme the provision of supports across the Human Capacity and Infrastructure dimensions, coupled with continued support in building Networks & Relationships, is required.

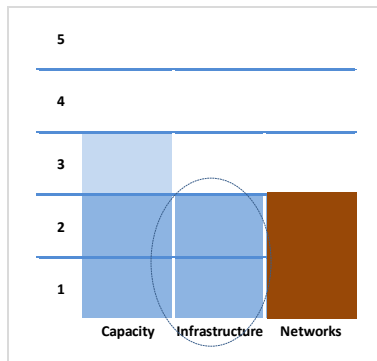




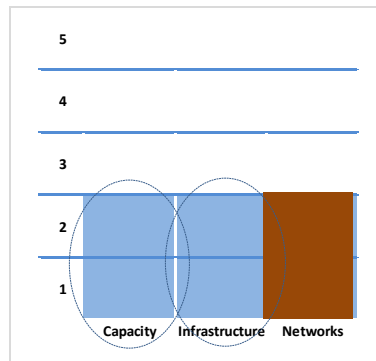
*Finfish Aquaculture*



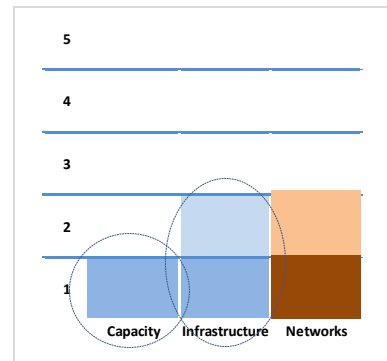
*Shellfish Aquaculture*



*Subsea Resources*



*Security & Surveillance*



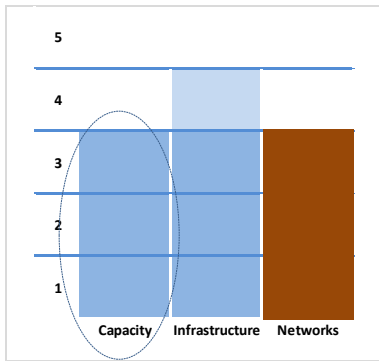
*Legal*

### **Moving Networks Capacity from “Established” to “Collaborative”**

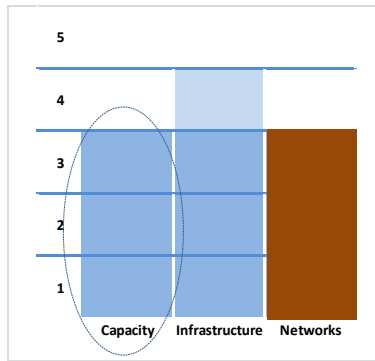
The practices that were identified in the “Established” level with regard to Networks & Relationships are strengthened and developed at the “Collaborative” level. In particular, the involvement of industry and policy making interest move from participation to theme definition. Similarly, the level of 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.

#### **Requirement**

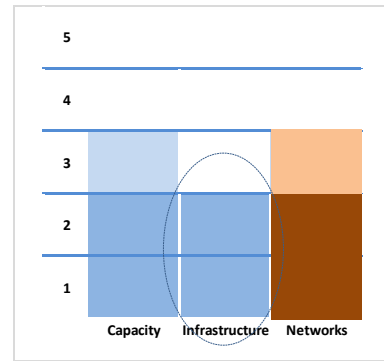
There are a number of research themes that would appear to be at the “Established” level on the Networks & Relationships dimension. While these are candidates for supports to promote a development of capacity to the “Collaborative” level, it should be noted that in very few instances will this result in an overall rise in capacity across the model dimensions. In these instances, supports need to be applied across a number of dimensions as outlined below.



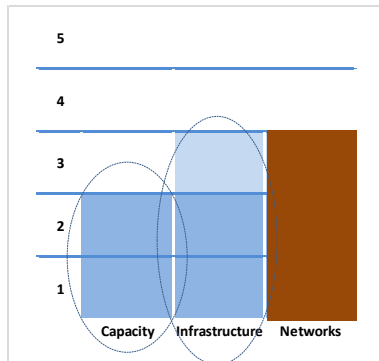
*Planning & Governance*



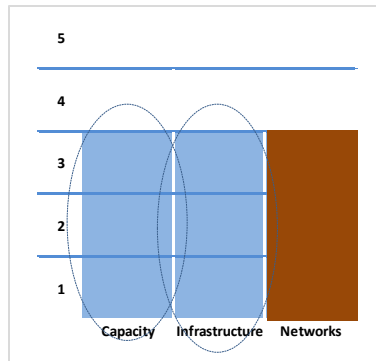
*Information & Spatial Tech.,  
Analytics & Modelling*



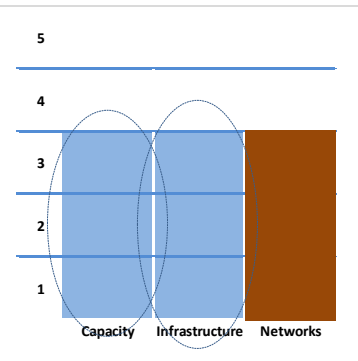
*Wild Fisheries*



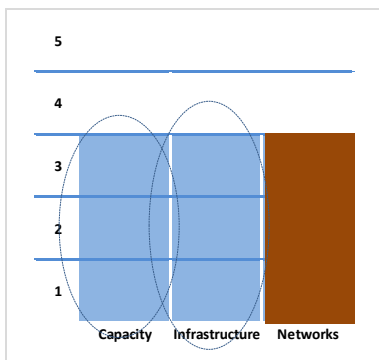
*Renewable Energy*



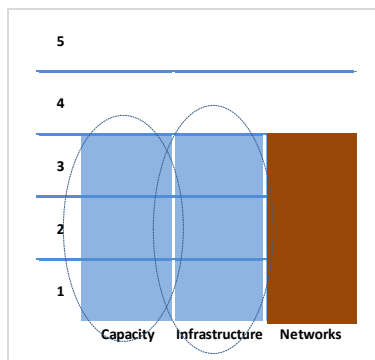
*Ocean Observation*



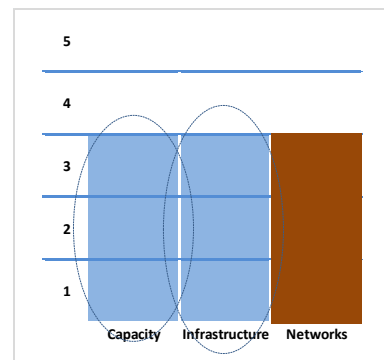
*Seaweeds*



*Advanced Technology*

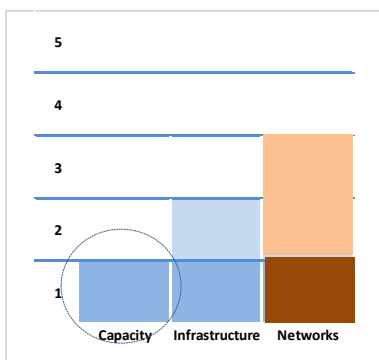


*Biodiversity, ecosystems &  
Food-webs*



*Biodiscovery*

In the case of the Business Development research theme, concentration of effort needs to be applied to the Human Capacity dimension in the first instance.



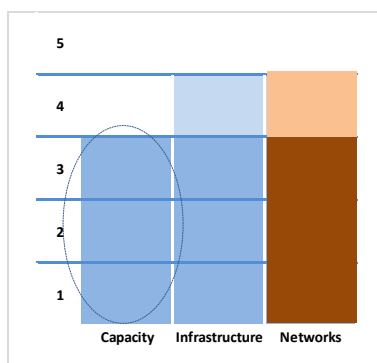
*Business Development*

## Moving Networks Capacity from “Collaborative” to “Translational”

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.

### Requirement

On analysis, only one research theme exhibits a requirement for support in this transition in relation to the Networks & Relationships dimension – Socio-Economics. This implies that, for the immediate future, targeted interventions such as access to international standards and policy-making, coupled with human capacity building, would achieve the most impact.



*Socio Economics*

## STATEMENT OF STRATEGY

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The preparation of this National Marine Research & Innovation Strategy has included:

- The development of a Research Capability Maturity Model for marine related research themes
- A detailed assessment of these themes including;
  - o A review of the major policy and sectoral drivers relevant to the theme
  - o An assessment of the research capacity at a national level that exists for the theme
  - o A statement of the major research topic areas required in the theme
  - o A recommendation of research funding focus for the years ahead
- A review of the major funding requirements to advance the research capacity in each area across the dimensions of Human Capacity, Infrastructure and Networks & Relationships; together with a mapping of this requirement to existing funding instruments.

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**, implicitly articulated until this point, 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.

Marine research is a cross-cutting theme. This is highlighted in the National Research & Innovation Strategy, *Innovation 2020*, which positions marine as one of a number of societal challenge areas. Consequently, a range of agencies and government departments have a role in the promotion and funding of marine research as it relates to each of the themes identified in this strategy, such as food, energy and transport. 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 role of research funders

Various non-marine specific agencies and government departments engaged in policy 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 listed in this document. These bodies have their own mandate to fund research relevant to policy advice, development of research excellence and sectoral development as appropriate.

The framework and associated analysis articulated in this marine research strategy is intended to support all funders active in funding marine research to collectively advance national capacity and to ensure value for money. These research funders should also focus on collaboration and avoid duplication.

### **The role of the development agencies**

Development agencies, including Enterprise Ireland, the IDA, 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.

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 agencies to direct activity in the lower maturity levels. Such collaboration should include research funding, in particular co-funding.

### **The role of the Marine Institute**

The Marine Institute has a specific statutory remit in relation to marine research funding 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.

A further requirement in the realisation of a funding strategy for marine research is to complement and supplement these existing research supports where possible. The Marine Institute should do this by co-funding general research calls offered by other research funders in order to direct these call to the marine sphere.

## ANALYSIS OF RESEARCH THEMES

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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 over view 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
- Value Added Products

#### Advanced Technologies

#### Subsea Resources

#### Renewable Energy

#### Tourism

#### Transport

#### Security & Surveillance

### HEALTHY MARINE ECOSYSTEMS

#### Biodiversity, Ecosystems & Food Webs

#### Litter

#### Climate Change

#### Ocean Observation

### 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

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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:

(1) Bioresources; (2) Advanced Technologies; (3) Sub-sea Resources; (4) Renewable Energy; (5) Tourism; (6) Transport and; (7) Security and 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 possess 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 comprise species that exist naturally in the marine environment and those marine species that can be cultured, whether at sea or 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, principally harvested from wild fisheries, and supplemented by aquaculture, are used as food products and food ingredients. 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 and managing the impact of these activities.

Enhanced research capability is also required in established fields which offer significant interdisciplinary research potential, especially in marine biotechnology, to ensure Ireland can benefit from the myriad of opportunities it offers 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 industries 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**, which identifies on an ongoing basis topics for applied research.

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.

The **EU Common Fisheries Policy (CFP)** aims to continue to influence change in the harvesting and management of wild fish stocks. Blue Growth and the CFP 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.

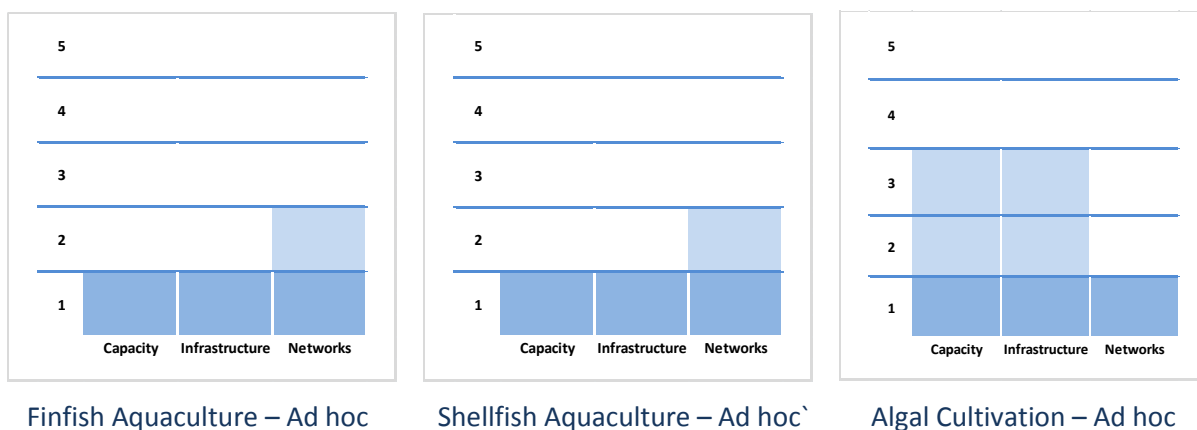
These themes and associated areas of focus are described in more detail in the following individual sub-discipline descriptions.

## Bioresources – Aquaculture & Biomass Production

### Overview

Aquaculture has a key role as a sustainable source of supply of materials for use as food and other 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 provides an additional source of raw materials for use in a variety of market areas.

### Research Capabilities - Maturity Assessment



Ireland’s aquaculture activity includes finfish, shellfish and algae (macro- and micro-algae) production and is the source of all cultivated biomass used in the creation of food and other bio-based products. 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. On-going research is mostly led by institutional based Principal Investigators funded from national and international sources but with little apparent collaboration nationally. With the exception of algae, undergraduates have little or no exposure to aquaculture.

## Research Topics

The National Strategic Plan for Sustainable Aquaculture Development highlights a number of specific research topics. In general terms these relate to: Breeding and Species Selection, Disease and Stock Health, Feed Supply, and Production & Production Systems including multi-trophic production.

In addition to these topics, there is significant opportunity and need for research topics that span between this and other research themes. Specifically, the application of expertise from the Ocean Observation, Climate Change and Biodiversity, Food webs & Ecosystems themes is required.

## Focus of Funding

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.

Improved understanding of the health status and welfare of farmed 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 sources of feed for fed-fish is not sustainable. The 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 and expansion of 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. Such developments will also require improvements to fish welfare and health and a minimisation of biosecurity risks. In this context there is a need for insights to better understand the economic and environmental impact of alternative/contrasting 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.

## Bioresources – Wild Resources

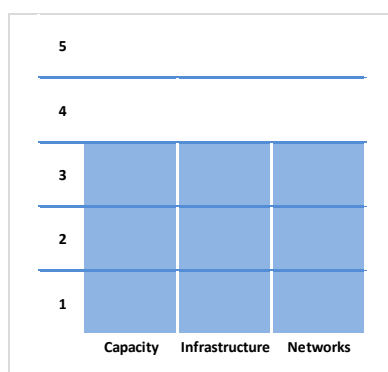
### Overview

Building from the current 16 percent of all animal protein consumed globally, scope exists to increase the contribution of fish in resolving food security issues, but requires the sustainable exploitation of wild fisheries. Research related to the capture of species from wild resources under this heading includes all “wild” resources – fish, algae, sponges and other invertebrates harvested for food or other uses.

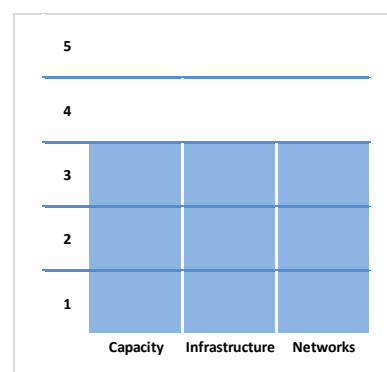
The wild capture of fish and shellfish from waters around Ireland is the largest source of marine biomass with close to 290,000 tonnes landed in Ireland during 2014. The wild fisheries sector is managed in accordance with EC regulations under a common fisheries policy and production is limited by the imposition of quotas, with most of the landings used as human food. Nevertheless there are a significant number of “non-quota” species that represent an important portion of the marine ecosystem whose productivity remain poorly understood.

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) used in the production of alginates and other polysaccharides. Other uses for wild harvested seaweed include animal feeds and animal health, horticulture, cosmetics, food and food ingredients.

### Research Capabilities - Maturity Assessment



Wild Fisheries - Established



Seaweeds – Established

Research maturity across fisheries and seaweeds is at the “**Established**” Level of maturity. Research capabilities in fisheries and seaweeds are based around a small number of Principal Investigators in three institutions, some of whom are internationally renowned experts in their areas reflected in them having secured European and national research funds. Undergraduate teaching programmes in Marine Sciences include modules in phycology, and marine biology, including fisheries. There is,

however, an absence of postgraduate training programmes. Whilst there are no large-scale harvesting of species other than fish 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.

### **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. The move from fisheries management to ecosystems management is more urgent than ever, with an expanding number of disciplines needing to be brought to bear upon the topic.

Specifically, improved understanding of the impact of warming oceans coupled with changes to ocean acidity are needed to inform the future planning of assessment and monitoring regimes. Further understanding of the ecosystem is required, including 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 quantify available biomass and to support the definition and introduction of sustainable harvesting regimes for species of commercial interest is required.

### **Focus of Funding**

Given the established nature of wild resources research in Ireland, research funding under this theme should be focused on widening the inter-disciplinary nature of projects. Funding should also be directed to ensure that these projects are informed by and deliver a mix of both policy and industry advice.

In line with the research topics outlined above, research projects should provide information which can be used to facilitate resource management. The modalities and execution of wild marine harvesting has to be informed by accurate assessments and feedback from monitoring systems designed to provide knowledge about stocks and the sustainability of harvesting. 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.

In the case of wild seaweed harvesting, the licensing regime does not treat this resource as either a wild fishery or an aquaculture activity. Best practice investigations that can inform future licensing regulations for seaweed harvesting, and that are linked to sustainable harvesting regimes for species of commercial interest is warranted to preserve and sustainably utilise such stocks.

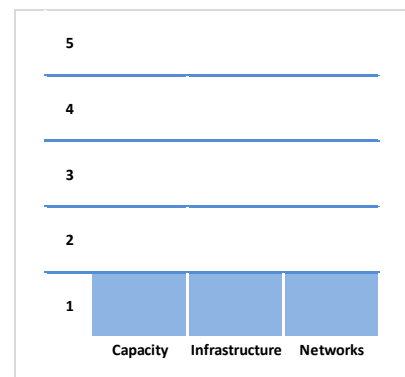
## Bioresources – Processing for Food and Other Use

### Overview

Both wild harvested and cultured marine bioresources, sometimes described as marine biomass, are processed as a step in a number of value-chains. 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 no 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- and micro-algae, although 'industrial' finfish species may also play a role, provides Ireland's research providers 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, 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 Seafood Development Programme, 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 refining marine biomass.

## Focus of Funding

As noted above, Ireland's established processing sector relies on processing innovations developed by suppliers of equipment, and this is reflected in an "Ad-hoc" level of research maturity across the theme. As a consequence 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 and food provenance.

Research infrastructure in this theme needs to support the goal of expanding the use of marine bioresources as the source of ingredients in 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.

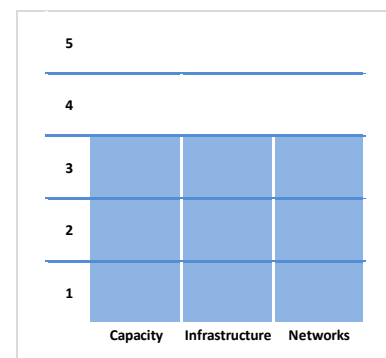
## Bioresources – Value Added Products

### Overview

Value Added Products from bioresources refers to those products that can be extracted from Biomass and used as input material for high-value products. European policy concerning the bioeconomy highlights not only the need for food production systems to be more sustainable, but also identifies marine bioresources as a source of novel processes and products. 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. However, it is not only food and health areas that offer opportunities for marine derived compounds. 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. A solid foundation of internationally recognised research involving a cohesive group of Principal Investigators from Irish universities and 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. 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 applications areas that provide possible research themes.

These include food, feed and food ingredients, health and pharmaceutical applications, as well as a scope in materials science and engineering.

### **Focus of Funding**

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. 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 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 provides a solid foundation 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 **Innovation2020** 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.

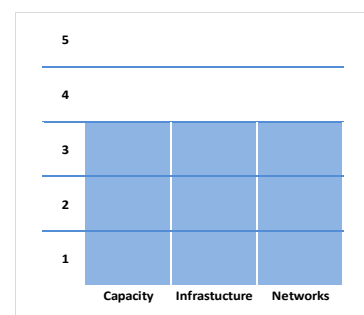
From a European policy context, the EU’s **Blue Growth** strategy recognises the role of technology in creating an opportunity to harness the untapped potential of Europe’s oceans.

**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 **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 monitoring platforms; data acquisition and communications; data processing, cataloguing and management; informatics, visualisation, virtual/augmented reality; forecasting and prediction; robotics and autonomous systems; materials and systems that can withstand harsh environments.

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 harvesting 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.

## Subsea Resources

### Overview

Yet to be discovered hydrocarbon resources that exist offshore Ireland could generate clean gas as a transition fuel that complements intermittent renewable energy resources as Ireland decarbonises its energy generation to meet GHG emission 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. 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.

### Context

The **White Paper on Ireland’s Energy Policy** (“Ireland’s Transition to a Low Carbon Energy Future 2015-2030”) identifies geosciences as an important component of energy research.

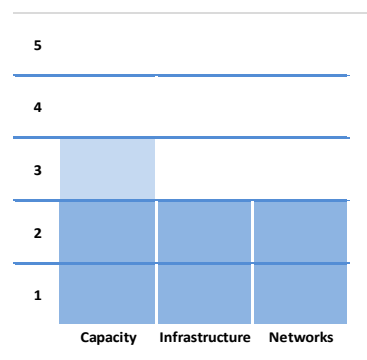
**Innovation 2020** commits to implement research related actions in the Energy White Paper.

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, establishment of a number of relevant research centres has further



cemented this capability and is serving to de-risk exploration. Despite near collaborative levels of human capacity and significant infrastructure in terms of data (e.g. seismic and technical data available through programmes such as INFOMAR and data via the State aimed at promoting petroleum exploration), there remain gaps in terms of infrastructure availability. Scope also exists for further inter-institutional, industry and international collaboration.

## **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;
- Innovative techniques for predicting the location and nature of resources; and
- Improved methods for optimising the production of resources.
- Environmental baseline acquisition studies

Research priorities identified by the global oil and gas industry are also applicable in the Irish context.

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, will play a key role in delivering ambitions for the increased research and innovation to support the sustainable development of subsea resources. Although Ireland’s geoscience research base has a track record of industry engagement, funding should be focussed on improving and increasing access to research infrastructure, through funded open access programmes; and expanding the high-end computing capacity in Ireland.

Funding to support “Networks & Relationships” should be focused on promoting the opportunities generated by Irish research to international oil and gas and mining sectors.

## 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.

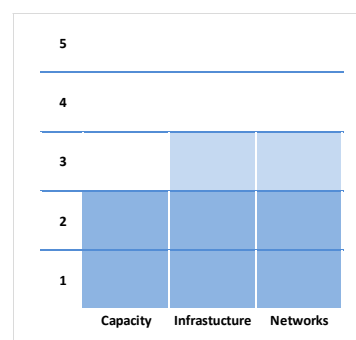
**Harnessing Our Ocean Wealth** and the strategic framework outlined in the report of the **Development Task Force** includes “Energy from the Ocean” - reflecting Ireland’s marine renewable energy potential. The European Union has also identified Ocean Energy as a sector that has high potential for sustainable 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 (OREDP)** 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.

### Research Capabilities - Maturity Assessment

The renewable energy field of research has been assessed as “**Defined**”, albeit close to being at the “**Established**” level in relation to Infrastructures and Networks & Relationships. There is a strong human capacity base with relevant research centres in place. However, the extent to which this base 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 suit 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 Horizon2020 funding.

## 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.
- 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

### 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 marine and coastal tourism. 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 current **Tourism Capital Development Fund** may support development in many coastal areas and in particular along the Wild Atlantic Way.

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

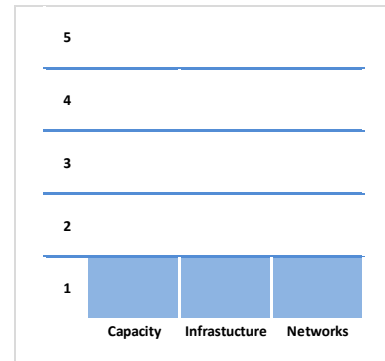
At a European level, the **EU Atlantic Action Plan** has a number of tourism related priorities.

There are a range of other regional and sectoral plans and initiatives prepared by organisations such as the Commissioners for Irish Lights and a number of the Harbour Companies.



## Research Capabilities - Maturity Assessment

The Marine & Coastal 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 Topics

Research activity should focus on: innovation in delivering new visitor experiences, performance and destination development benchmarking, consumer research and trends, citizen 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:

- Support an annual National Marine Tourism Research Forum to align existing expertise and resources amongst the academic and agency community. This would act as a catalyst to harnessing existing expertise and resources and encourage Marine Tourism research and papers for more conferences and events. Consideration should also be given to a Research Award
- Fund a Marine Tourism Innovation scheme that supports coastal community / academic partnership research and develop new visitor experiences harnessing marine resources and maritime heritage, technology and links with other marine disciplines
- Fund PhD positions to support EU and funding applications that will add to the national tourism and maritime development agenda

## Transport

### Overview

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

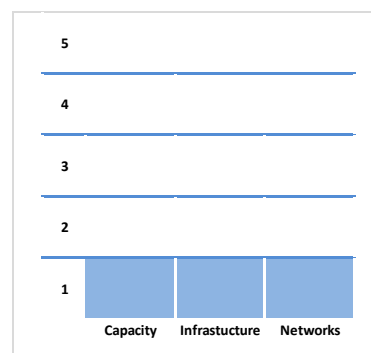
Ireland's **National Ports Policy** is focused on facilitating a competitive and effective market for maritime transport services, and **Harnessing Our Ocean Wealth** identifies the role the maritime and ship leasing field plays in the competitiveness and connectivity of the economy.

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

Continued support for cross-cutting research on maritime transport needs to be leveraged to establish capacity for direct transport related research. This could be improved by strengthening and adding maritime fields to existing transport research centres.

The need to stimulate industry collaboration in research could be achieved through a targeted SBIR programme that 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 help address capacity in the short term and could be used as a stepping stone to building a more sustainable research capacity in this area.

A dedicated effort to catch up with front runners like the Netherlands, Sweden, Finland and France on 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.

### Context

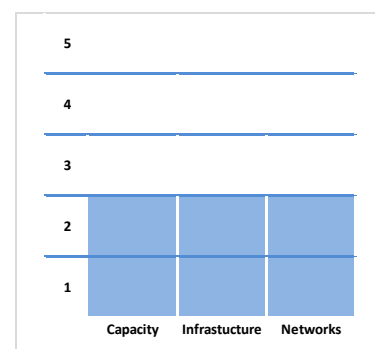
Maritime Safety, Security and surveillance is one of the key enablers of **Harnessing Our Ocean Wealth**. The report of the **Development Task Force** proposed a demonstrator initiative under the thematic area of "Integrated Marine Capacity & Capability". Ireland's **White Paper on Defence** highlighted 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 Council'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 a 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 level and incentivising research linkages with the emerging enterprise base could help create the platform for more industry funded research in the medium to long term.

## HEALTHY MARINE ECOSYSTEMS

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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 key area of research is the related areas of **Biodiversity, Ecosystems and Food-Webs**. This strategy treats these topics together as, although they are often arrived at from the diverse perspectives of environmental protection and sustainable food production, 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 **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** 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, Litter, Ocean Observation, and Climate Change. 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 fundamental to economic growth and the sustainable use of marine resources. Such an understanding enables ecosystem goods and services derived from the marine resource to be managed and utilised into the future. Research in Ireland has mostly focussed on small-scale primary research resulting in a lack of understanding and knowledge regarding biological diversity, ecosystem functioning and marine food webs. There is an urgent need to develop scientific, technical and institutional capacities to expand the scope of research in the field.

### Context

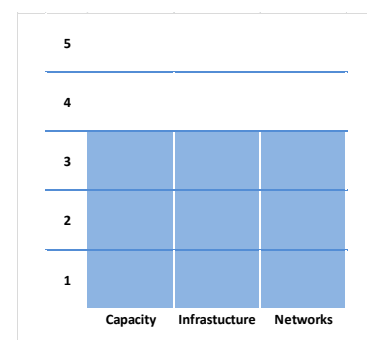
The need for focused research is driven by a number of international and national policies and legislation. At an international level, the **United Nations Convention on Biological Diversity (CBD)** provides the framework for the conservation and sustainable use of global biodiversity; while the **EU 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 Nature conservation Directives (**Birds and Habitats Directives**), Regulation 1143/2014 on **Invasive Alien Species (AIS)** and the **Marine Strategy Framework Directive (MSFD)**.

At a National level **Actions for biodiversity 2011-2016** is Ireland’s National biodiversity plan, which was 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 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”**. However, 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.



## 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 warning system for the identification and detection of non-native invasive marine species; and (4) Research that supports the development of monitoring programmes. This would include identifying risks to the Good Environmental Status (GES).

In addition, enhanced understanding of the dynamics and pressures on the marine environment will support future environmental protection and sustainable development. Such topics include: (a) Research in support of assessing the impacts of new and novel technologies; (b) Marine food web modelling for marine ecosystems in Ireland and; (c) Primary diet data analysis and research.

## Focus of Funding

A distinction needs to be made between funding to inform existing policy needs and funding for basic (blue skies) research. This will be essential to build and maintain a dynamic marine biodiversity research community in Ireland.

To create efficiencies in the available resources, a funding mechanism is required to support marine biodiversity and ecosystem function research networks to build on existing human capacity and better enable basic as well as applied research. The management of competitive research calls for marine biodiversity on the themes identified in support of all government departments 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 coding to support modelling activities.
- The support of a national research group who 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 the research area.



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, Marine Spatial Planning, Water Framework Directive, Habitats, OSPAR Commission and other transboundary requirements.

## Litter

### Overview

The extent of the world’s marine litter is attributed to increased human pressures on the oceans and the challenges associated with implementing and enforcing regional and international regulations and standards. Expansions in the level of economic and social activities that take place on the oceans and along coastal areas generate waste, creating a threat to both animal and human life. Increasingly complex manufacturing processes, coupled with demand for persistent and micro and nano-sized particles are creating increasingly complex challenges in the effort to reduce and remove litter. The need for proper and efficient waste management is widely recognised internationally as an issue that requires addressing worldwide.

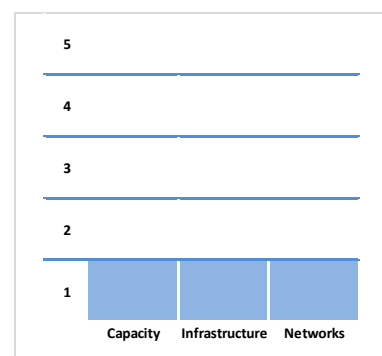
### Context

Ireland’s current approach to marine litter is largely driven by the **Marine Strategy Framework Directive** (MSFD). Under the MSFD, the descriptor applicable to marine litter is “*Properties and quantities of marine litter do not cause harm to the coastal and marine environment.*” Final indicators associated with the descriptor are needed, notably those relating to biological impacts and to micro-particles, as well as for the enhanced assessment of their potential toxicity.

From what was largely an aesthetic problem, the negative impact of marine litter is wide-ranging. Amongst the impacts highlighted are the entanglement of species in marine litter; ingestion of litter by marine species; alteration, damage and degradation of benthic habitats; reduced recreational, aesthetic and educational value of marine areas; and economic harm as a result of marine litter interfering with aquaculture, fishing, transport, tourism and leisure, and power generation. The abundance of micro-particles in marine habitats, mostly, though not exclusively originating from plastic materials is seen as a major global threat to marine life. Knowledge of these micro-plastics is scant, with major concerns that these particles have adverse effects on marine organisms.

### Research Capabilities - Maturity Assessment

The research capability of research related to marine litter in Ireland is assessed as “**Ad-hoc**”. Despite a number of active research projects, and some limited laboratory space, the field is relatively young in terms of development in Ireland. A number of institutions are collaborating internationally; however, in the main these projects are at an early stage.



## Research Topics

The overarching need to ensure environmental sustainability, position Ireland within the green economy and support the production of high quality food and other natural resource based products are drivers of research activity concerning marine litter. Major research areas associated with marine litter include understanding the sources, prevalence, and incidence of litter at macro, meso, micro and nano levels; the impact of marine litter on marine environments, on coastal areas and on animal and human populations; assessment and monitoring methods; and strategies to address the challenge of marine litter.

In light of Ireland's scarce resources and limited involvement in litter related research new thematic research should be directed towards specific priority areas listed, with a focus on ensuring Irish research participation.

## Focus of Funding

*Support the implementation of the MSFD:* Reaching good environmental status (GES) in the implementation of the MSFD is an immediate priority for Ireland. Research under this theme includes identifying actions required to ensure GES can be maintained; to generate data that can be used to substantiate the effect of remediation actions designed to reduce marine litter; and to understand the impact of marine litter on Ireland's natural resources.

*Ocean pollution:* The reduction of marine litter is a long-term goal for all regions. Research is required to identify measures that can lead to a reduction of marine litter originating from Ireland and Irish sources and to identify practical solutions to reduce the impact of marine litter on the quality of Ireland's ocean territories and on marine species.

*Monitoring and assessment:* The emergence of new threats from marine litter, particularly those associated with micro- or nano-particles is an opportunity for Ireland to draw from, build upon and deploy competencies from related areas (e.g. remote sensing, seabed mapping, oceanography, toxicology etc.) to identify and quantify such threats. Such an approach can be used to determine the origin of these materials, the risks they pose to sensitive environmental niches (such as the impact of plastic and microplastic litter on biota), and to provide the seafood and other sectors using marine bioresources with data concerning the human and animal health impacts of micro- and nano-particle litter.

## Climate Change

### Overview

Ireland's current capabilities in marine climate change 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 HEIs 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

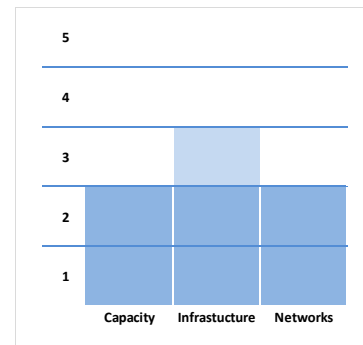
The **Fifth Assessment Report (AR5)** of the United Nations **Intergovernmental Panel on Climate Change (IPCC)** was completed in 2014 and contained extensive discussion and analysis of ocean warming, CO<sub>2</sub> emissions and related ocean acidification impacts. At **COP21**, all parties to the UNFCCC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

A range of international organisations are involved in advocating, coordinating and supporting climate change research. These include **CLIVAR, IOC, GOOS, Euro-GOOS, GCOS, Copernicus** as well as the **MCCIP** 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.

## 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. Given our shared sea area, it would be advantageous to collaborate meaningfully with UK, European and international researchers, networks and infrastructures.

## Focus of Funding

Meaningful policy advice and the provision of climate change 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 inter-disciplinary with impacts on a range of other research themes and topics in the marine, e.g., ocean observation, marine biodiversity, modelling).
- *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

### Overview

At a time when the impact of human activity on ocean and coastal processes is of growing concern, the transformation of ocean and coastal observational data into information enables good management of the human relationship with the ocean. Ireland has a significant capability with respect to seabed mapping. However, this expertise is concentrated in government bodies, with national research capability not reflecting this operational sophistication. Ireland's ocean observation infrastructure is limited but Irish researchers and industries have direct access to European Space Agency (ESA) satellite data. Ocean observation research capacity is concentrated in two centres with distributed pockets of niche research.

### Context

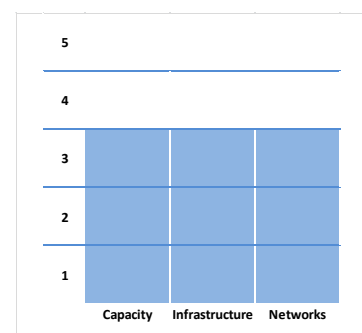
**A Framework for Ocean Observing** by the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012, seeks the co-ordination of ocean observations around “essential ocean variables (EOVs)”. The **Implementation Plan for the Global Observing System for Climate in Support of the 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, that 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**.

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**”. This reflects the somewhat fragmented nature of research in the field within the HEI sector, particularly in relation to direct in-situ observation capacity. However, there are collaborative levels of infrastructure with nationally available equipment pools, and those HEIs engaged in this research area are interactive internationally. There is also industry collaboration, but it is fragmented in nature. In the state sector



significant expertise has been developed in the Geological Survey of Ireland and the Marine Institute through the INFOMAR national seabed mapping programme and its predecessor, The Irish National Seabed Survey. Through the Atlantic Ocean Research Alliance strong international linkages are also established in terms of the mapping of the Atlantic resource

### **Research Topics**

There are three main business and policy drivers for ocean and coastal observation: (1) de-risking commercial operations in the marine sector by improving met-ocean and climate change modelling; (2) developing new cost effective sensors, power systems, high bandwidth communications, data processing and data interpretation and; (3) 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 increased evidence of the societal benefit of ocean observation and seabed mapping, through directed economic impact and enhanced understanding of ecosystem services. In this regard there are significant linkages between this research theme and those relating to Subsea Resources, Advanced Technologies, Climate Change, and Information and Spatial Technologies, Analytics and Modelling.

### **Focus of Funding**

The relatively developed research maturity assessment in this field hides a requirement for a range of funding supports in the Ocean Observation field.

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 are capable of deploying to and operating in the ocean environment. Similarly, Ireland's expertise in seabed mapping should be sustained and expanded by funding appropriate undergraduate and post graduate courses in an Irish third-level institute.

Support for research infrastructure, primarily in the form of ocean deployed data acquisition platforms, is required. Given the complexity of deploying ocean infrastructure, such infrastructure should be coordinated at national level. Inter-institutional access and collaboration in using these infrastructures should be encouraged through support instruments that encourage research collaborations and formal inter-institutional centres.

There is potential for the commercialisation of coastal and ocean observation products and services to meet legislative and resource management requirements. 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, the provision of a single interagency system to provide real-time operating, surveillance and monitoring data on activity offshore Ireland can provide the base layer to which all national agencies can add their specific data and make informed decisions.



## ENGAGEMENT WITH THE SEA

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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 Education & Ocean Literacy, Integrated Policy & Governance; Information & Spatial Technologies, and Engineering; 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. Research in this field is required to evaluate existing knowledge in the broad area of Seas and Ocean Health, the impact this has on citizens (including on human health) and to develop new ways to communicate this. Education is a wider concept, concerned with the communication of facts and imparting knowledge in relation to the marine with a view to equipping citizens to make informed decisions in relation to the marine environment and to ensure that the skills required for the ocean economy are in place.

### Context

The **Integrated Maritime Policy for the European Union** aims to raise the visibility of Europe's maritime identity and economic potential among Europeans.

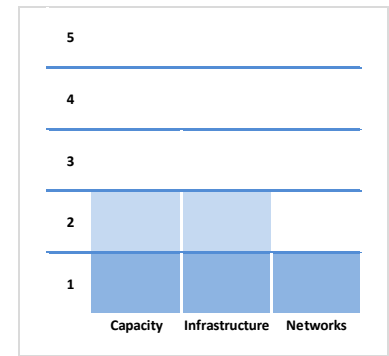
The "engagement with the sea" goal of **Harnessing Our Ocean Wealth** aims to strengthen Ireland's maritime identity and increase awareness of the value, opportunities and social benefits of engaging with the sea. The reports of the **Enablers Task Force on Maritime Spatial Planning** and the **Development Task Force** produced recommendations that are directly relevant to Ocean Literacy.

The **Expert Group on Future Skills Needs (EGFSN)** assessment of the future skills needs, labour market supply and demand trends across Ireland's existing and emerging marine sectors recommended establishing a Marine Discover Programme, modelled on the SFI Discover Programme, to raise awareness among students at all levels of career opportunities in the marine economy.

The "**Galway Statement on Atlantic Ocean Cooperation**", signed in Galway in May 2013 by the European Union, Canada and the United States of America, promotes ocean literacy to facilitate citizen's understanding of the value of the Atlantic. The Atlantic Ocean Resource Alliance (AORA) Coordination and Support Action, funded under Horizon 2020, aims to provide Europe, the United States and Canada with relevant and responsive information on the status of a number of research areas to meet scientific and industry needs in the North Atlantic.

## Research Capabilities - Maturity Assessment

Despite “Defined” levels of Human Capacity and Infrastructures, this research theme remains at an “Ad-hoc” level due to underdevelopment of the Networks & Relationships dimension of research capability.



## Research Topics

At a national level, research is required to support and assess all the relevant actions from *Harnessing Our Ocean Wealth* where “Engagement with the Sea” is referenced. Inter-disciplinary research, in particular research in topic areas that span the humanities & social sciences and science, technology & engineering disciplines are central to this. This includes those that investigate understanding and dissemination of knowledge in the broad area of Seas and Ocean Health and the impact this has on citizens, such as Human Health.

Actions that support the findings of the *Expert Group on Future Skills Needs* are required for developing Ireland’s ocean economy.

## Focus of Funding

A national Ocean Literacy Programme should be supported; building on experience and expertise generated in projects such as the Horizon2020 “Sea Change” and “ResponSEAbLe”.

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 – playing a key role in achieving the goal of increasing “engagement with the sea”.

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 programmes have the potential to rapidly raise the skill base available to the ocean economy in Ireland.

## Integrated Policy and Governance

### Overview

As our marine resources become increasingly viewed as the basis for a 'blue economy', so 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.

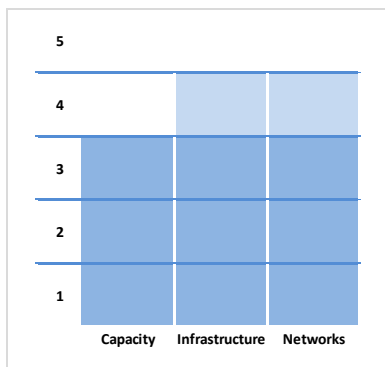
Research and Innovation has a major role in supporting the development of both sectoral and the integrated marine policy agendas, at national, EU and international level. Research is essential in supporting societal challenges and cross-cutting priorities such as food security, climate change and sustainable 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

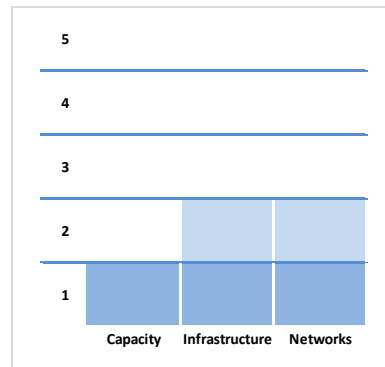
With the increased focus on our oceans, there is a growing realisation of the necessity for increased collaboration, cooperation and innovative governance of the oceans and the activities that it supports.

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 **Marine Spatial Planning** and the work of the **Development Task Force**.

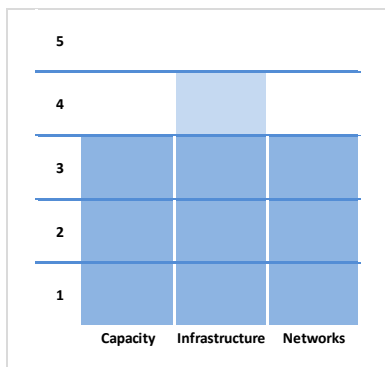
## Research Capabilities - Maturity Assessment



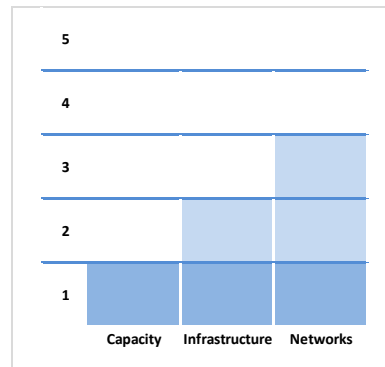
Socio Economics – Established



Legal – Ad Hoc



Planning & Governance – Established



Business Development – Ad-Hoc

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 under human capacity, infrastructure and networks:

### 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 key institutions include NUI Galway and University College Cork and also through collaboration in the SFI centre for Marine and Renewable Energy (MaREI). In the State sector, scientific, technical, legal and economic capacity and expertise is available (although limited) across a number of semi-state organisations and also government departments. A third component is IMERC- the Irish Maritime and Energy Resource Cluster incorporating expertise from UCC, CIT and the Irish Naval Service.

The capacity ranges from “established” in the area of Economics and Planning & Governance, through to “ad-hoc” in respect of Legal, and Business Development. Although a number of high-

profile Principal Investigators are involved in a range of research 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 and Business Development, dedicated capacity and capability is planned in the state sector to address capacity required to develop a Marine 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. These include courses in Coastal and Marine Environments, Marine Biology, Applied Coastal and Marine Management, Applied Science / Fisheries Management, Development and Conservation, Marine Renewable Energy, Applied Science-Ecological Assessment (marine modules), Ecosystem Conservation & Landscape Management (partial marine), and Natural Resource Economics and Policy - Economic & Environmental Modelling (partial marine). Education and training in Maritime Law is also available. In 2016, a new Masters Programme in Maritime Law was announced. The initiative is led by UCC in conjunction with the Office of the Attorney General and the Naval Service.

Spread across other 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 Marine 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, however, 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 (OREDPA), 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.



## 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 organisations, such as the ESRI, to enhance innovation in the areas of socio-economics and planning, governance and business development
- Commissioning and promoting 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 suite of progress indicators and socio-economic targets
- 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 purposes, e.g. from BIM
- 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 OREDP
- 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 organisations and established research and teaching institutions. This concept, which broadly encompasses Information & Communications Technology, Geographic Information Systems, data analytics and data and numerical modelling, is a foundation discipline for progress in many of the other themes in this strategy.

### 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**.

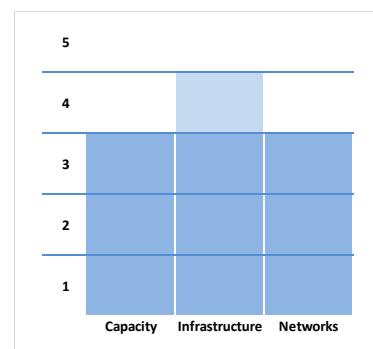
Systems and services are also being developed at European level that support or facilitate national activities, for example the **European Space Agency Sentinel observation platforms**, and the Copernicus Programme **Marine Environment Monitoring Service (CMEMS)**.

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 easily capable in participating in large-scale research centres. A key inhibitor identified has been sourcing adequate industry funding for such centres.



## Research Topics

As data streams grow and access to them simplifies a focus on the potential outcomes of analysis on that data is growing and presents opportunities.

Building on the test labs, instrumentation and sensors in MaREI, the Galway Bay Ocean Observatory, and elsewhere, there is opportunity to build data analytics capability from the data being generated.

With our extensive North Atlantic seabed, there is opportunity to innovate in the creation of substantial digital ocean platforms with operational and commercial benefits.

## Focus of Funding

- Support to key institutions and networks to get on an ESFRI Research Infrastructures Roadmap.
- Along with Horizon 2020 and other programmes, utilise the ESA funding opportunities to get Irish-led marine EO and ICT projects.
- Provision of non-technical financial and management support to spin-outs to ensure commercial fundamentals are stable while delivering on innovation.
- Ensure existing funding supports are available at high-risk stages and at sufficient levels for companies, thereby supporting innovation.
- Use of Small Business Innovation Research (SBIR) as a mechanism to enable public sector bodies to connect with technology businesses (marine or currently non-marine) to provide innovative solutions to specific marine sector challenges.

## Engineering

### Overview

A myriad of core engineering disciplines support coastal/offshore projects. Ireland is well served by the third-level sector that produces upwards of 500 engineering graduates annually. 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.

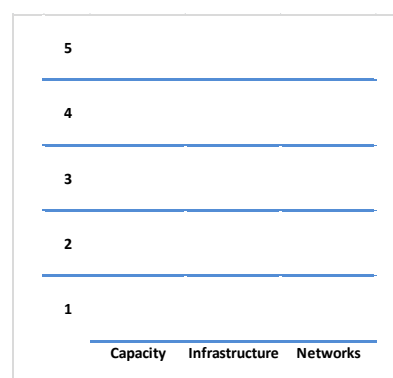
### Context

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, failing to be 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 will be needed 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)

## 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

